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ABSTRACT

The guide presents lesson plans from "NOVA" which targets middle school and junior high school students and meet the National Science Education Standards. Lessons include: (1) "Neanderthals on Trial"; (2) "Fireworks"; (3) "Secrets, Lies and Atomic Spies"; (4) "Bioterror"; (5) "The Missing Link"; (6) "Shackleton's Voyage of Endurance"; and (7) "Fire War". (YDS)

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NOVA

Spring 2002 Teacher's Guide

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Fire Wars

Airs May 7, 2002

www.pbs.org/nova/

SE035475

Learning is most effective when the lessons are exciting and the teaching is inspired. This is the challenge NOVA strives for week after week. As an educator, you understand this challenge. Your ability to find fresh and inspiring new approaches to learning is the key to igniting young minds.

Helping people achieve successful futures has been the cornerstone of Northwestern Mutual for nearly 140 years. Our sponsorship of NOVA underscores our commitment to this tradition.

The Northwestern Mutual Foundation is proud to offer you another season of the *NOVA Teacher's Guide*. We hope it will become an important resource for you as you discuss this dynamic, and award-winning series in your classroom.

Best wishes for a successful school year.

Edward J. Zore
President and Chief Executive Officer

Northwestern Mutual
Foundation

The Park Foundation is committed to education and quality television. We are pleased to be able to advance the work of NOVA, the preeminent television series in science education. As you know, through study of science, young people acquire skills, knowledge, and—most of all—an intellectual curiosity.

We wish to salute you, as teachers of science, for fostering that intellectual curiosity and passion for investigation among your students. Those skills will serve them well for a lifetime. It is our hope that this NOVA guide will assist you in your effort.

We are grateful for your commitment to teaching.

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Contents & Broadcast Schedule

NOVA Teacher's Guide Spring 2002

page		Earth & Space Science	General Science	Life Science	Physical Science	Social Studies	NOVA Activity
2	**NOVA in the Classroom** Find out what's new on NOVA Online and how NOVA is being used in classrooms nationwide.						
	Death Star* Tuesday, Jan. 8 • www.pbs.org/nova/gamma/	●			●		
4	**Neanderthals on Trial*** Tuesday, Jan. 22 • www.pbs.org/nova/neanderthals/		●			●	
8	**Fireworks!*** Tuesday, Jan. 29 • www.pbs.org/nova/fireworks/		●		●		
12	**Secrets, Lies, and Atomic Spies*** Tuesday, Feb. 5 • www.pbs.org/nova/venona/		●			●	
16	**Bioterror* (R)** Tuesday, Feb. 12 • www.pbs.org/nova/bioterror/			●		●	
	Nazi Prison Escape* (R) Tuesday, Feb. 19 • www.pbs.org/nova/naziprison/		●			●	
20	**The Missing Link*** Tuesday, Feb. 26 • www.pbs.org/nova/link/			●			
	Cancer Warrior* (R) Tuesday, March 19 • www.pbs.org/nova/cancer/			●			
26	**Shackleton's Voyage of Endurance* (2 hours)** Tuesday, March 26 • www.pbs.org/nova/shackleton/		●			●	
	Holocaust on Trial* (R) Check local listings • www.pbs.org/nova/holocaust/		●			●	
	Vanished!* (R) Check local listings • www.pbs.org/nova/vanished/		●				
30	**Fire Wars* (2 hours)** Check local listings • www.pbs.org/nova/fire/		●		●		
	World Trade Center*†‡ Check local listings • www.pbs.org/nova/wtc/		●		●		
	Submarines, Secrets, and Spies* (R) Check local listings • www.pbs.org/nova/subsecrets/		●			●	
	Tales from the Hive* (R) Check local listings • www.pbs.org/nova/bees/			●			
	Lost King of the Maya* (R) Check local listings • www.pbs.org/nova/maya/		●			●	
	To the Moon* (R) Check local listings • www.pbs.org/nova/tothemoon/	●					
42	**NOVA Video Catalog**						
48	**Ordering Information**						

Schedule Changes

Because of potential programming changes after March 26, 2002, NOVA programs listed here may not air on their currently scheduled date. **Please check your local listings after March 26 for final program information.**

Up-to-date schedule information can be obtained at: **www.pbs.org/nova/schedule.html** or by signing up for the Teachers electronic mailing list at: **www.pbs.org/nova/teachers/listsubscribe.html**

Because of scheduled changes, some NOVA programs do not have lessons.

- one-year off-air taping rights
- (R) repeat program
- ∞ working title
- lesson within this guide
- lesson online at www.pbs.org/nova/teachers/

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NOVA in the Classroom

Stories of Endurance

Dear Educators,

This season we present two compelling programs that I believe have special relevance to the challenges confronting our country since the events of September 11, 2001.

One of these programs, "Shackleton's Voyage of Endurance," explores the extraordinary leadership and sheer human determination that kept 28 men alive while stranded for nearly two years in the bitter cold of the Antarctic. Interviews with relatives, original footage from the expedition, and heartfelt diary entries reveal the strategic leadership decisions of Sir Ernest Shackleton and the importance of ingenuity and steadfast determination when trying to overcome life-threatening obstacles. At a time when heroism has taken on a new meaning, Shackleton typifies the kind of leader who puts the lives of those under his care ahead of any other consideration.

The second program, "Fire Wars," describes a catastrophic year of wildland fires. We follow goups of firefighters as they use teamwork, fire science, and new firefighting technologies to battle a series of disastrous fires that swept through milllions of acres of wilderness in the fire season of 2000. Most of all, the program explains that fire is a powerful natural force that demands respect from all of us.

I believe these programs will provide important science stories and valuable examples of how leadership, teamwork, and the human spirit can help us rise to any challenge and, together, overcome adversity.

Paula S. Apsell
NOVA Executive Producer

Visit NOVA Online's New Teachers Site

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C Keyword Search List

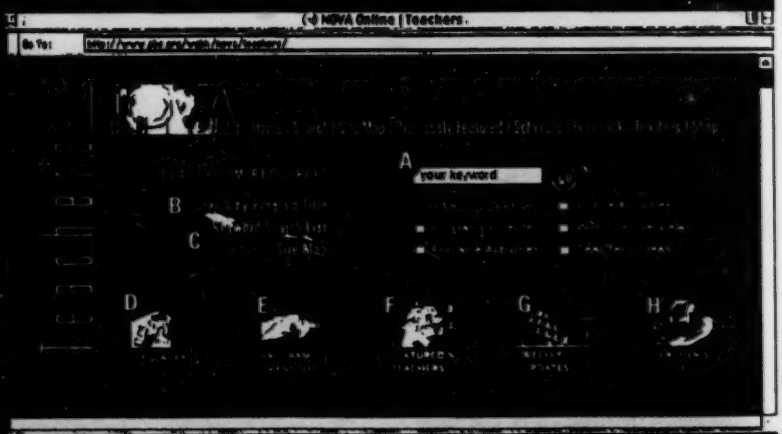
D This Week

E Program Transcripts

F Featured Teachers

G Weekly Updates

H Teacher's Guide



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NOVA Featured Teacher

Placing Value on Maya Math

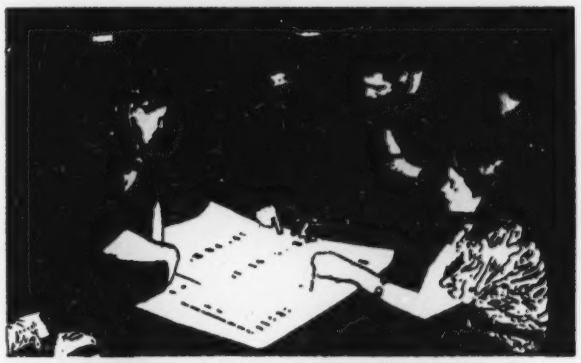
Bob Miller likes a challenge. In this case, incorporating a grade-level focus on the Maya into his mathematics classes.

Seventh graders at Inza R. Wood Middle School in Wilsonville, Oregon, study the chronology and culture of early civilizations of the Americas. The school's emphasis on integrated technology and participation in the MayaQuest distance learning program encouraged the seventh-grade teaching team to design an interdisciplinary unit on the Maya.

For Miller, the NOVA program "Lost King of the Maya" aired at just the right time. Miller, who has been teaching for 12 years, showed the NOVA program over several class periods. Students were already familiar with the Maya system for writing symbols; Miller complemented that knowledge with an activity on place value and number theory similar to the one in the Spring 2001 *NOVA Teacher's Guide* using resources he found on the Web.

Miller usually introduces place value by having students look at a base system other than base 10. This time he devised a "pure" base 20 system for students that was similar to the Maya number system. Students were asked to be archaeologists and were given a worksheet with some Maya numerals and their Arabic equivalents, as if these were the few numbers that had been decoded. Students then determined the values of other numerals and described the general structure of the Maya number system. Students converted the numbers from one number system into the other, noting patterns and formulating rules as they did so.

Miller says students figured out the rules for representing numbers in the ones place fairly easily. Determining the rules for the upper place values (20s and then 400s) proved increasingly difficult. Students also had to adjust to a system of numbers that were read vertically. Miller observed that once students let go of their conventions, they started to apply what they knew of the regularity of the base 10 system to the base 20 system.



From left Agatha Brazinski, teacher Bob Miller, Mike Campos, and Krista Anderson attempt to determine the rules that govern the way Maya numbers are written using some examples of Maya numbers that have been converted into Arabic numbers.

Students then examined the Maya Long Count Calendar and mapped Maya intervals onto their customary system for reporting dates. Finally, students wrote reports to a fictitious foundation describing the structure of the Maya number system and explaining how they reached their conclusions. Students hypothesized how Maya mathematicians added and subtracted two numbers. A few students even attempted multiplication. The letter was scored using a math rubric and the district writing rubric.

For more information about Miller's project, you can e-mail him at: **millerb@wlwv.k12.or.us**

Become a NOVA Featured Teacher

We'd like to hear from YOU! Tell us how you're using a NOVA program, the *NOVA Teacher's Guide*, or NOVA Online in your classroom. Your lesson idea will become a part of our Teachers' Ideas section online and you will become eligible to become a NOVA Featured Teacher. If you are chosen, we'll send you and your students six free NOVA videos or two Classroom Field Trip kits of your choice.

Send your ideas to:
Erica Thrall
WGBH
125 Western Avenue
Boston, MA 02134
erica_thrall@wgbh.org

Or post them at:
www.pbs.org/nova/teachers/ideas/send.html

Program Contents

Scientists present a wide variety of evidence, and its interpretation over time, in an ongoing debate over Neanderthals' place in evolution.

The program:

- describes the changing view of Neanderthals over the last 150 years and illustrates the different interpretations that scientists have held over this time period.
- follows the debate of whether Neanderthals were ancestors of *Homo sapiens*, or the result of a separate evolutionary path.
- documents an analysis of Neanderthal DNA, which supports the idea that Neanderthals were not direct ancestors of modern humans.
- introduces arguments from those who believe that Neanderthals and moderns were separate species and could not interbreed, making Neanderthals an evolutionary dead end; and those who believe that Neanderthals and moderns were members of a single species that did interbreed, giving Neanderthals a role in the ancestry of modern humans.
- illustrates the subjective nature of interpreting archaeological sites by detailing the errors of past interpretations of artifacts found in a French cave.
- reveals modern excavation techniques of the French cave site and interpretations of the artifacts there.

Before Watching

1. The illustration below left, published in 1909, represents one of the first depictions of Neanderthals. The photograph on the right represents a modern interpretation. Before showing the program, display both depictions of Neanderthals and ask students to draw conclusions about the subject pictured in each.

What conclusions would you draw about each of these individuals?

After Watching

1. Have students look again at the two depictions of the Neanderthals. What differences do they see in how the Neanderthals are represented? How have the representations changed? What might account for these differences?

Activity Setup

Objective

To interpret a Neanderthal artifact found at a cave site in Slovenia.

Materials for each student

- copy of the *What Is This?* activity sheet on page 6

Procedure

1. Tell students that there is still much to be learned about Neanderthal life. Increasing evidence points to the idea that Neanderthals may have been more sophisticated than previously thought.
2. In this activity, students will be looking at and trying to determine the nature of an illustration of an artifact discovered in 1996 at a Neanderthal camp in Slovenia. The actual artifact was about 4.3 inches (11 centimeters) long.
3. Organize students into groups and distribute a copy of the *What Is This?* activity sheet to each student. Have students read the information provided about Neanderthal life and brainstorm what they believe the artifact might be. Have students defend their reasoning.
4. Once students are finished, have each group present its conclusions about the artifact to the class. Make a chart of students' ideas and then discuss other possibilities for what the artifact might be. After all ideas are presented, have each group decide whether it still supports its original conclusions, citing why or why not. What additional information would students need to help them identify the object?
5. At the end of the activity, tell students that when this was originally found, some scientists believed it was a flute made by the Neanderthals. Most scientists now believe that the artifact is actually a bone that has been pierced by the canine teeth of a predator.

Standards Connection

The activity found on page 6 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard G:
History and Nature of Science

Nature of science

- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, and identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

Grades 9-12

Science Standard G:
History and Nature of Science

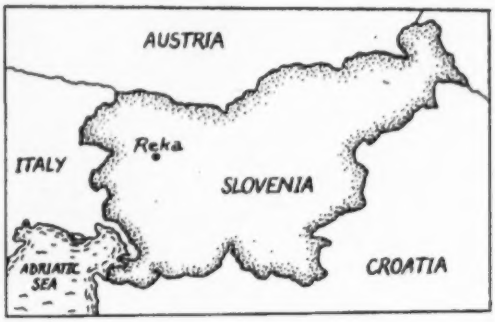
Nature of scientific knowledge

- Scientific explanations must meet certain criteria. First and foremost, they must be consistent with experimental and observational evidence about nature, and must make accurate predictions, when appropriate, about systems being studied. They should also be logical, respect the rules of evidence, be open to criticism, report methods and procedures, and make knowledge public. Explanations on how the natural world changes based on myths, personal beliefs, religious values, mystical inspiration, superstition, or authority may be personally useful and socially relevant, but they are not scientific.

What Is This?

NOVA Activity **Neanderthals on Trial**

The artifact at the bottom of the page was discovered in a cave in western Slovenia. It is believed to be between 43,000 and 82,000 years old and determined to be from the thighbone of a juvenile cave bear. It was found at a former Neanderthal camp known as Divje Babe I near the town of Reka. But what is this artifact? What, if anything, was it used for? Use the information about Neanderthal life below to see whether you can figure out what this artifact might be.



Neanderthal Life

Who were the Neanderthals, the *hominids* that existed before and during part of the same time as modern *Homo sapiens*? While scholars disagree about exactly who the Neanderthals were, they have some idea of how they lived from sites that have been excavated in Europe and Western Asia. The Neanderthals lived from about 200,000 years ago to around 30,000 years ago, during the Ice Age.

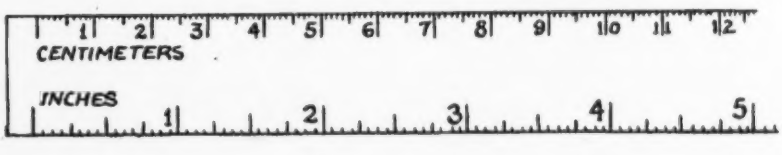
They made tools from stone gathered nearby their camps and presumably used them for such things as shaping wood, butchering animals, and scraping hides. They lived in caves, rock shelters, and open-air sites. They used fire. There is only limited evidence of artistic expression. A few pierced animal teeth have been found, probably worn as personal adornment, but no cave paintings or figurative carvings on bone or stone have been found. There is no way of knowing, however, whether their artistic talents took another form that would not be preserved, such as wood carving or storytelling.

In terms of diet, they subsisted on meat from hunting small game and herd animals such as wild horses, deer, and caribou. Larger and more dangerous animals such as mammoths and bears were either ambushed or trapped, or—more likely—scavenged after another predator had killed them. They also ate plant foods, although little of the evidence for this aspect of their diet has survived. The question of whether Neanderthals deliberately buried their dead, as opposed to merely disposing of bodies in trash heaps at their living sites, is still controversial. There is good evidence from at least one site that they cared for disabled individuals.

Questions

Write your answers on a separate sheet of paper.

1. What do you think this object is? What might it have been used for? What level of confidence do you have in your conclusion? Defend your reasoning.
2. What else could this be?
3. What other information would you want to get to help you figure out what this might be?



Activity Answer

Neanderthals were named after Neander Valley, the German valley in which their remains were first discovered. They have been classified both as part of the same species to which contemporary humans belong (*Homo sapiens*) and as a separate species only distantly related to modern humans.

Ideas about the nature of Neanderthals have often been at extremes, either that they were of limited intelligence, and not in any way related to contemporary humans, or that they were smart, and very much like contemporary humans. One of the challenges for anthropologists today is to try to understand the Neanderthals as they truly were.

In paleoanthropology, as in the other historical sciences, scientists create theories from fragmentary evidence; if those theories can't be disproved, they are considered valid interpretations of the past until further evidence invalidates them.

In the case of the item students were interpreting, some scientists believed the artifact was a flute, supporting the idea that Neanderthals exhibited artistic expression. However, all Neanderthal finds to date suggest that Neanderthals neither had the bone-working technology to make such an item, nor any hint of artistic behavior that would be the source of such an instrument, evidence that refutes the flute theory. Some scientists theorize that the holes instead were made by a carnivore puncturing the bone with its canine teeth.

Resources

Books

Shreeve, James.
The Neandertal Enigma: Solving the Mystery of Modern Human Origins.
New York: Willam Morrow & Co Inc., 1996.
Examines the scientific evidence and controversy surrounding the fate of Neanderthals.

Tattersall, Ian.
The Last Neanderthal: The Rise, Success, and Mysterious Extinction of Our Closest Human Relatives.
Boulder, CO: Westview Press, 1999.
Uses recent discoveries to explain why Neanderthals continue to be so perplexing a scientific mystery.

Trinkaus, Erik, and Pat Shipman.
The Neanderthals: Changing the Image of Mankind.
First edition. New York: Knopf, 1993.
Reveals how the personal philosophies of scientists and the cultural ethos in which they lived combined to determine their view of prehistoric humans.

Article

Bower, Bruce.
"Doubts Aired Over Neanderthal Bone 'Flute.'"
Science News, April 4, 1998, page 215.
Summarizes findings from two scientists who believe that the Neanderthal cave bear thigh bone is not a flute, but rather a bone that appears to have been punctured and gnawed by carnivores.

Web Sites

NOVA Online—Neanderthals on Trial
www.pbs.org/nova/neanderthals/
Provides a NOVA producer's account of making a balanced film on a contentious issue, compares Neanderthal and Cro-Magnon skulls, shows how experts trace ancestry using a type of DNA only passed down along maternal lines, and offers a way to interpret bones and artifacts.

Scientific American—The Last Neanderthal
www.sciam.com/explorations/1999/110899nean/index.html
Reports on some of the changing views about Neanderthals.

Program Contents

NOVA investigates the science and psychology of fireworks.

The program:

- chronicles the first use of fireworks more than 1,000 years ago by the Chinese, who made firecrackers from gunpowder, and shows the historical relationship between gunpowder and fireworks over time.
- traces the allure of fireworks over time, from their beginnings as a magical marvel used during medieval times—when much of life was lived in the dark—to their use in Renaissance royalty gatherings and at public celebrations for masses of people.
- notes that the three basic ingredients of a firework—potassium nitrate, charcoal, and sulfur—have not changed much from when they were first used.
- profiles Zambelli's Internationale, a pyrotechnic company run by an Italian-American family with generations of fireworks experience.
- details how colors, sounds, and shapes are created, and how experts continually seek to improve their displays.
- describes how a firework is conceived, made, launched, and exploded.
- Portrays the intricate org zation of Boston's annual July 4 display and shows how a comp network controls the la of 5,700 fireworks at that t.
- introduces Pyro Boy, who raps fireworks to his body to create a 1-minute human fireworks display.
- reviews safety measures that govern the firework industry.

Before Watching

1. Ask students to describe what they remember about the fireworks they have seen. When are fireworks usually used? What are the components of a fireworks display? What kinds of feelings are generated by watching a fireworks display?

2. To help students understand how fireworks have evolved, have them do the *History of Fireworks* activity on page 9 before watching.

Louis Zambelli packs a single-burst star firework with the lift powder that will propel it into the sky.

After Watching

1. Fireworks involve the use of explosives, yet people choose to work with these dangerous elements on a daily basis. Would students like to work in a fireworks factory? Why or why not?

2. Fireworks have been used in celebrations for centuries. What other ways do cultures choose to celebrate occasions in such an exalted manner? What are some common themes found in grand celebrations?

Note: The Pyro Boy segment of this program shows behavior that may be inappropriate for student viewing. Please preview the program for its appropriateness in your classroom.

Activity Setup

Objective

To trace the evolution of various aspects of fireworks from their invention to today.

Materials for each student

- copy of the *History of Fireworks* activity sheet on page 10

Procedure

1. Fireworks have been around for more than 1,000 years. To help students understand how they have evolved, have students investigate their invention and use over time.
2. Organize students into five groups and distribute the *History of Fireworks* activity sheet to each student. Assign students in each group to take notes on the evolution of fireworks in the following areas as they watch the program:
   - the time period over which they have been used
   - the chemistry involved
   - the techniques used
   - the type of use
   - the frequency of use
3. After students watch, have each group conduct additional research on its assigned topic. Have group members synthesize their information on one page.
4. Have the time period group create a relative scale timeline of the period in which fireworks have been used, starting with the use by the Chinese, and following through to Renaissance, Victorian, and modern-day uses. The timeline should be large enough for the other groups to add their information.
5. Have each group add its information to the timeline and, when all groups are done, have each group present its information. After all groups have presented, discuss with students what occurred during each phase of the timeline. What are the major ways in which fireworks have changed over the course of their history?

Standards Connection

The activity found on page 10 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard G:
History and Nature of Science

History of Science

- In historical perspective, science as been practiced by many different cultures. In looking at the history of many peoples, one finds that scientists and engineers of high achievement are considered to be among the most valued contributors to their culture.

Grades 9-12

Science Standard G:
History and Nature of Science

Historical Perspectives

- In history, diverse cultures have contributed scientific knowledge and technological inventions. Modern science began to evolve rapidly in Europe several hundred years ago. During the past two centuries, it has contributed significantly to the industrialization of Western and non-Western cultures. However, other, non-European cultures have developed scientific ideas and solved human problems through technology.

History of Fireworks

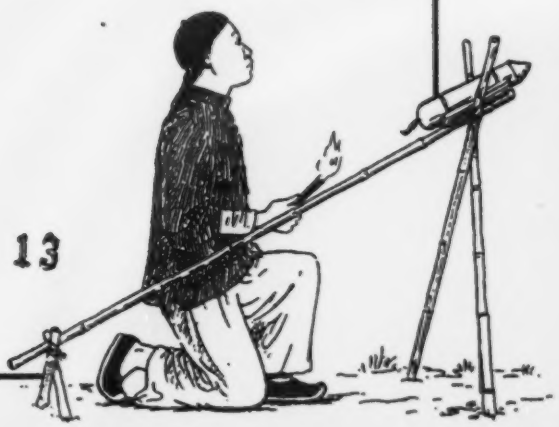
NOVA Activity **Fireworks!**

Fireworks have been around for more than 1,000 years, and have been used and thought about in many different ways during that time. In this activity, find out some of the ways that fireworks have evolved.

Procedure

1. As you watch the program, take notes on your assigned group topic.
2. After watching, discuss your notes with your other group members. Once you do additional research, work with other members to create a summary page of all your findings.

Notes



Activity Answer

The chemistry of fireworks has remained basically the same since their discovery. Gunpowder, which is the basis of many fireworks, is supplemented with metal powders to create sparky effects. The three basic ingredients are potassium nitrate (75 percent), charcoal (15 percent), and sulfur (10 percent). Saltpeter enhances the flame. A propellant is used to launch the fireworks into the sky.

The Chinese are credited with discovering fireworks by creating a mixture of charcoal, sulfur, and saltpeter that would explode if enclosed in a small place. The Chinese would use firecrackers to scare away evil spirits. In medieval times, when people spent most of their time in the dark, people were fascinated by the sparks and explosions that created light. During the Renaissance, the military was responsible for both war artillery and for fireworks used during peacetime. In 1575, the Earl of Leicester hosted Elizabeth I and capped a multi-day feast with fireworks. Rulers would often use fireworks in ceremonies to prove they could create magic for their subjects. In the 1730s, fireworks went from being used for dramatic purposes to more common uses.

It wasn't until the 1830s that pyrotechnicians learned how to add color to fireworks. Replacing potassium nitrate with potassium chlorate, an energetic oxidation agent, raised the combustion temperature of the fireworks to 2,000 degrees C (3,632 degrees F), allowing for a wider range of colors to be used. Colors are created by adding metal salts to the mixture. Each metal salt produces light in a specific wavelength (sodium salts create yellow; copper salts, blue; strontium nitrate, red; barium nitrate, green; charcoal or other form of carbon, orange). Pyrotechnicians are now trying to figure out how to create letters. Modern-day uses range from small to large celebrations. State laws vary concerning the type of fireworks allowed; some states allow none.

Resources

Book

Lancaster, Ronald, Roy E. A. Butler, J. Mark Lancaster, Takeo Shimizu, and Thomas A.K. Smith. **Fireworks: Principles and Practice.** New York: Chemical Publishing Company, 1998.
Opens with a world history of the manufacture and display of fireworks.

Web Sites

NOVA Online—Fireworks!
www.pbs.org/nova/fireworks/
Provides program-related articles, interviews, interactive activities, resources, and more.

The Chronicle's Pyrotechnicians
www.sfgate.com/chronicle/events/fourth/pyro.html
Profiles a family-run pyrotechnic firm and offers factual information about the cost and composition of modern fireworks.

Fireworks and Pyrotechnics
chemistry.about.com/cs/fireworks/
Links to several sites about the chemistry and physics of making fireworks. Includes links to the chemistry of firework colors, the science and history of fireworks, and a description of some 150 chemicals used in pyrotechnics and explosives.

Fireworks: The Science Behind the Spectacle
library.thinkquest.org/15384/
Offers the history of pyrotechnics, the chemistry of fireworks, the physics of fireworks, and the construction of fireworks.

Rocket History
www.grc.nasa.gov/WWW/K-12/TRC/Rockets/history_of_rockets.html
Explains how rockets were developed in tandem with or as derivatives of fireworks.

Secrets, Lies, and Atomic Spies

Airs Tuesday, February 5, 2002 • www.pbs.org/nova/venona/

Program Contents

NOVA explores the story of the VENONA project, a 37-year American codebreaking effort challenged with deciphering theoretically impenetrable codes used by an extensive Soviet spy network throughout the United States, Canada, and Great Britain.

The program:

- reviews the history of codebreaking in the United States, from the time of Pearl Harbor through the Cold War.
- reveals that from the 1930s to early 1950s, the Soviets had nearly 300 spies in the United States infiltrating every branch of the government, including the White House and the Manhattan Project.
- explains that knowledge gained by these spies allowed Joseph Stalin's Soviet Union to build nuclear weapons years earlier than expected.
- profiles the skills and methods used by VENONA project personnel who eventually broke the Soviet cipher.
- examines the effect of the government's decision to keep the VENONA project secret—even among some government agencies—until 1995 and how that decision reshaped thinking about the origins of the Cold War.

Before Watching

1. To help students understand the program, review the following terms with them: *code, cipher, plain text, base code, encoded message, additive, enciphered message,* and *indicator.* (See *Activity Answer* on page 15 for more information.)

2. Have students brainstorm what makes a good codebreaker. What kinds of personality traits, characteristics, or skills do students think would be good to have? As students watch, have them take notes on the backgrounds and specialties of people involved in breaking the Soviet ciphers.

Ethel and Julius Rosenberg ride in a marshal's van to the Federal House of Detention after being found guilty of nuclear espionage. They were executed on June 19, 1953.

After Watching

1. Have students consider whether they agree or disagree with the government's decision to wait until 1995 to inform Americans about the VENONA project. What were some of the implications of this decision?

Activity Setup

Objective

To break a code and explore the skills required in this form of analytical thinking.

Materials for each student

- copy of the *Puzzling Messages* activity sheet on page 14

Procedure

1. Tell students they will be working to crack two coded messages. Organize students into teams and provide each student with a copy of the *Puzzling Messages* activity sheet.
2. Have students do Part I of the activity by unscrambling the five words. The first word, TODAY, was chosen because it's easy to unscramble.
3. Tell students that the unscrambled words hold the clue to the code. Have students look at the unscrambled words in relation to the code name and see if they can determine the pattern used to scramble the words.
4. Once they have figured out the code, students can move onto decoding the second message in Part II of the activity. This message uses the same strategy, but a different code, and is more complicated because the words are not all the same length and more letters are exchanged.
5. After students have decoded both messages, discuss the results. What about decoding the messages was easiest? What was the most difficult?
6. To close the activity, ask students to describe what skills they believe were helpful in breaking the codes. List these on the chalkboard. From this listing, construct a questionnaire and have students present it to another class before students in the other class try the 1245 code task. After the code is broken, identify the codebreakers. Did the questionnaire successfully classify who would be the best at breaking the code?
7. As an *extension*, have students code their own messages and exchange them with other students to decode.

Standards Connection

The activity found on page 14 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard G:
History and Nature of Science

Science as a human endeavor

- Women and men of various social and ethnic backgrounds—and with diverse interests, talents, qualities, and motivations—engage in the activities of science, engineering, and related fields such as health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.

Grades 9-12

Science Standard G:
History and Nature of Science

Science as a human endeavor

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.

89467 25342 13109 795

79384 22493 80694 5938

19538 88964 24958 89584 39584 38584

15323 69483 49583 66943 79558

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Puzzling Messages

NOVA Activity **Secrets, Lies, and Atomic Spies**

During World War II and the Cold War, the intelligence agencies of Great Britain and the United States gathered people together for the purpose of breaking the codes of other nations. These people were good with languages, crossword puzzles, chess, word scrambles, mathematics problems, and other puzzles. Good memories, broad vocabularies, and wide-ranging interests were also important. Do you have the "right stuff" to break a secret code? Try this activity and see.

Procedure

Part I

① You have received information that the following code is somehow directly related to its name, 1245.

② First unscramble the words below. Then look at the unscrambled words in relation to the code name, 1245, to help you determine the rules governing this code.

1245 Code

OTDYA IEGTH HSISP ELAEV PSANI

Questions

Write your answers on a separate sheet of paper.

① What does this message say?

② What are the rules governing this code?

Part II

① Your supervisors were so happy with your code-breaking skills that they've assigned you to break this new message that has just come in. The only information you have about it is that the same group of people who coded the previous message coded it.

② Apply what you learned about the rules governing the 1245 Code to this code in order to break it.

132547 Code

EHFARWS ROTDENC SREONSE LNFOFEI
IWNYMAD LNIØSDA

Questions

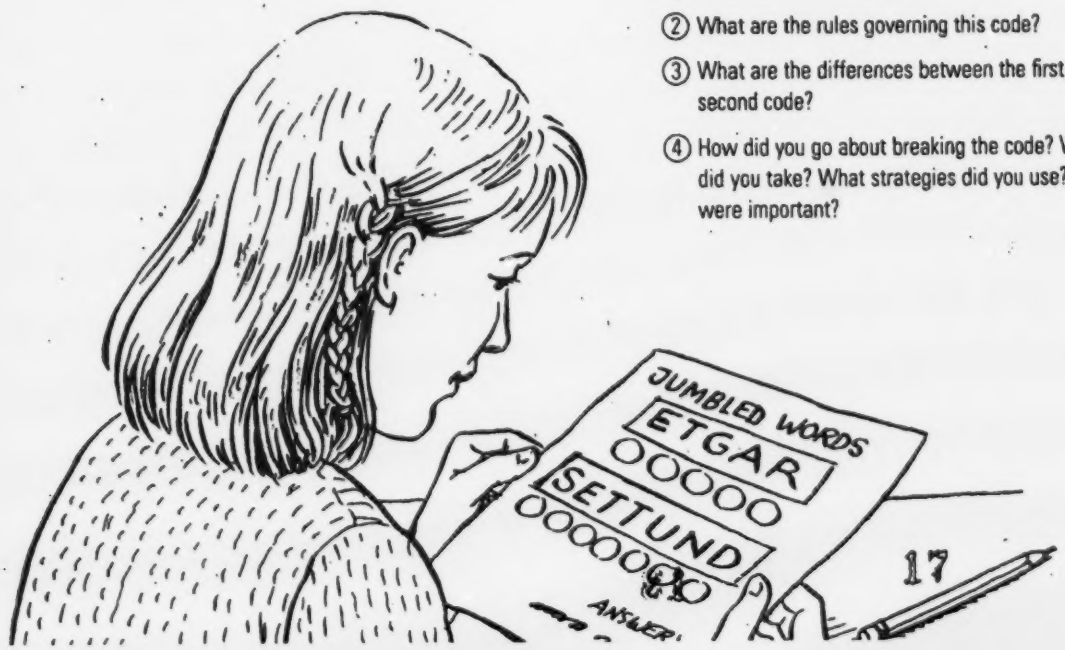
Write your answers on a separate sheet of paper.

① What does this message say?

② What are the rules governing this code?

③ What are the differences between the first and second code?

④ How did you go about breaking the code? What steps did you take? What strategies did you use? What skills were important?



Activity Answer

Codes are symbols, letters, or letter groups that represent whole words or concepts. Ciphers are messages in which letters or symbols replace real letters. Encrypting a cipher is done one letter at a time using a cipher code. Codes that are particularly difficult to break usually contain an additive. The process of stripping off the additive is known as cryptanalysis.

The following are some common terms in codebreaking, with an example of how each applies to coding.

Term	*Example*
Plain text: The text of the message.	attack at dawn
Base code: A list of number codes, usually five numbers long, that represent each word of text.	03960 (a) 74903 (at) 55148 (attack) 10263 (attacker)
Encoded message: A message that has been assigned base code numbers.	55148 (attack) 74903 (at) 69042 (dawn) 63012 (period)
Additive (or key): A number from a separate page of numbers is added to the code; this is called an additive or key.	87743 (additive)
Enciphered message: A completed message that includes an additive or key.	55148 (attack) 74903 (at) 69042 (dawn) 63012 (period) 87743 (additive)
Indicator: A number encoded in each message that tells the recipient which page of additive numbers to use from her key pad to decipher the message.	73112 (indicator for page in code book) 55148 (attack) 74903 (at) 69042 (dawn) 63012 (period) 87743 (additive)

The first message in the activity reads:
TODAY EIGHT SHIPS LEAVE SPAIN

The 1245 code that is used to encode and decode consists of pairs of numbers that govern how the message is encoded and decoded, as well as information on how many letters make up each code word.

1/2 = The first and second letters are transposed.
4/5 = The fourth and fifth letters are transposed.
5 = The last digit in the code indicates the length of the letter group; the plain text message is broken into five-letter increments. The missing number 3 denotes that the third letter remains unchanged.

To make the message easy to decode, the letter group length is equal to the length of all of the words. Usually the words are not all the same length and the letter group may be larger or smaller than five.

The second message reads:
FRESHWATER CONDENSERS OFFLINE ON MIDWAY ISLAND

The 132547 code also consists of pairs of numbers that govern how the message is encoded and decoded; it just has one more set of numbers than the previous code:

1/3 = The first and third letters are transposed.
2/5 = The second and fifth letters are transposed.
4/7 = The fourth and seventh letters are transposed.
7 = The plain text message is broken into seven-letter increments. The missing number 6 denotes that the sixth letter remains unchanged.

The message is decoded by reversing the steps. The order of exchanges is also reversed; fourth and seventh, second and fifth, and finally, first and third. A ø is added to fill the last group to seven letters. In the second message, words are different lengths so students will have to regroup the letters to see the plain text message.

In the second message, code groups are divided into arbitrary groups, not words. This code is much harder to break by inspection because students will have to regroup the letters to see the plain text message.

Resources

Book

Budiansky, Stephen.
Battle of Wits: The Complete Story of Codebreaking in World War II.
New York: Free Press, 2000.
Tells how the United States and the United Kingdom broke Japanese and German codes.

Web Sites

NOVA Online—Secrets, Lies, and Atomic Spies
www.pbs.org/nova/venona/
Provides program-related articles, interviews, interactive activities, resources, and more on the VENONA project.

VENONA—Soviet Espionage and the American Response 1939–1957
www.cia.gov/csi/books/venona/venona.htm
Provides access to American documents revealing key intelligence decisions of the period, as well as selected VENONA messages in translation.

Program Contents

NOVA presents a special program on the science of germ warfare that reveals previously unknown details of the secret biological warfare programs conducted by the Soviets and the United States during the Cold War.

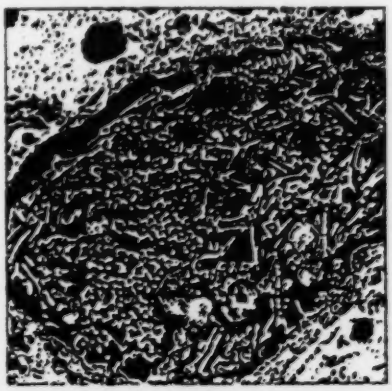
The program:

- follows three New York Times reporters as they delve into the past and present of biological weapons development.
- visits abandoned Soviet germ factories in central Asia and goes to Kazakhstan, where dozens of Soviet scientists worked in the world's largest bioweapons facility.
- profiles two Soviet germ scientists who defected to the United States in the early '90s and shared details of the Soviet bioweapons program.
- interviews the chief of product development at the U.S. Army's Fort Detrick facility, who discloses the history of the U.S. bioweapons program.
- explores evidence of Saddam Hussein's secret bioweapons program and speculates on its possible links to terrorist groups.
- notes that recombinant DNA technology allows scientists to genetically manipulate germs in order to make them more deadly.
- profiles ways the United States is working to fight bioterrorism.

Note: This program contains information about biological diseases that may be inappropriate for your students. Please preview it to determine its appropriateness for your classroom.

Before Watching

1. Review with students the terms *bacteria, toxin, antibiotic,* and *vaccine* (see *Activity Answer* on page 19 for more information).



This colored scanning electron micrograph shows a cluster of anthrax bacteria in a lung capillary.

After Watching

1. Discuss the program with students to help them process the information they have just seen. What about the program most affected them? What did they find most surprising? What would they like additional information about? Use student responses to help shape your lesson on how to help students learn more about bioterrorism.

Activity Setup

Objective

To help students learn more about the October 2001 anthrax attacks and their aftermath.

Materials for teacher

- copy of the *Getting Informed* teacher sheet on page 18

Procedure

1. When trying to help students learn more about the threat of bioterrorism, first make sure they do not feel excessive anxiety related to these issues. You can help them feel more comfortable by continuing normal routines. Students will react differently to trauma depending upon their age. For teenagers, the American Psychological Association notes that it is important to learn what preconceptions they may hold about the threat, and to help clear up any misinformation they may have. (See the "What Are Bioagents?" and "Who Says What" activities on your teacher sheet.) Some older children may also benefit by engaging in activities in which they can make a personal contribution that will benefit others.
2. According to the American Academy of Pediatrics, children should be allowed to express their fears and concerns. It is also important to let students know that their caregivers, schoolteachers, local community leaders, and federal government are doing everything they can to protect them from harm. To help students understand this, have them do the "What's Being Done?" activity on your teacher sheet.
3. Monitor students' reactions to discussions about anthrax and bioterrorism. If students seem to exhibit changes in their normal behavior, such as being overly aggressive or withdrawn, consider consulting a mental health professional trained in trauma care about the students' behaviors. See "Whom to Contact" on the teacher sheet for one organization that can help.

Standards Connection

The activity found on page 18 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard F:
Science in Personal and Social Perspectives

Risks and benefits

- Risk analysis considers the type of hazard and estimates the number of people likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.
- Important personal and social decisions are made based on perceptions of benefits and risks.

Science and technology in society

- Societal challenges often inspire questions for scientific research, and social priorities often influence research priorities through the availability of funding for research.

Grades 9-12

Science Standard F:
Science in Personal and Social Perspectives

Personal and community health

- The severity of disease symptoms is dependent upon many factors, such as human resistance and the virulence of the disease-producing organism. Many diseases can be prevented, controlled, or cured.

Science and technology in local, national, and global challenges

- Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.

Getting Informed*

NOVA Activity **Bioterror**

Although some students have heard about bioterrorism, particularly the anthrax bacterium, the idea of a biological attack may seem unreal to them. The unexpected nature of the anthrax attacks, as well as the fact that most students and adults had not heard about the disease prior to fall 2001, may cause students to react differently to the news. Providing facts about anthrax and other agents may help alleviate some fears. Be conscious of providing age-appropriate answers to your students when discussing these issues.

What Are Bioagents?

Bioagents are biological agents that can be used for biowarfare. Anthrax is considered one of the most likely bioagents to be used by bioterrorists. Students likely will have heard many different facts about anthrax and may have formed misconceptions about the disease. To explore students' understanding, have each student write down three facts they know and three questions about the disease and hand them into you. (Tell students they do not need to identify themselves.) Discuss students' facts and questions, clarifying as needed. (See *Activity Answer* on page 15 for more information.) Repeat the exercise with other bioagents students may have heard of, such as smallpox, plague, botulism, tularemia, and Ebola virus.

Who Says What

Have students investigate media reports about 21st century bioterrorism. Before they watch the NOVA program, organize students into five groups to take notes on 1) bioweapons development in the former Soviet Union, 2) bioweapons development in the United States, 3) obstacles to developing bioweapons, 4) obstacles to delivering bioweapons, and 5) facts about anthrax and smallpox.

After watching, have groups report on each category. Provide the same groups with five other recent media sources and have them research how each covered the five categories and report their findings to the class. How do the reports compare? Which sources gave the most facts? Which sources gave the least? What might account for any factual differences? What emotional tone, if any, did the reports convey?

***Sources:** Centers for Disease Control, National Institutes of Health, U.S. Postal Service

What's Being Done?

All levels of government are responding to the bioterrorist attacks. To help students understand the role of various groups and agencies, have them investigate and report on actions being taken at the local, state, and federal level. Some resources for this information include:

Linguistic/Behavioral Analysis of Anthrax Letters
www.fbi.gov/majcases/anthrax/amerithrax.htm
Includes information about the analysis of the anthrax-laced letters mailed to television anchor Tom Brokaw, the New York Post, and Senator Tom Daschle.

Office of Homeland Security
www.whitehouse.gov/homeland/
Details current efforts by the Office of Homeland Security.

StatePublicHealth.org
www.statepublichealth.org/index.php
Lists directories of state health agencies and contact information for current state health officials.

State and Local Efforts and Key Contacts
www.bt.cdc.gov/STAndLocal/
Provides information about specific state and local project efforts associated with bioterrorism preparedness and response and includes information on emergency contacts.

U.S. Department of Health and Human Services
www.hhs.gov/hottopics/healing/biological.html
Includes links to what agencies such as the Centers for Disease Control and the Food and Drug Administration are doing to counter bioterrorism.

Whom to Contact

The National Association of School Psychologists provides information for parents, educators, mental health professionals, and others as they cope with the unsettling current events. Visit NASP's Web site for more information at:
www.nasponline.org/NEAT/crisis_0911.html

or contact:
NASP
4340 East West Highway
Suite 402
Bethesda, MD 20814
phone: (301) 657-0270
fax: (301) 657-0275
e-mail: center@naspweb.org

Activity Answer

The bioterrorism attacks on the United States in fall 2001 may have seemed to some like a new kind of warfare, but biological warfare is not new. It dates back centuries; one of the earliest uses occurred in the 6th century B.C. when the Assyrians poisoned enemy wells with rye ergot, a fungal disease.

Anthrax is a disease caused by the bacterium known as Bacillus anthracis, which resides inactive in soils. Warm-blooded animals such as cows, sheep, and goats can contract the disease by eating food contaminated with spores. It is rare to find infected animals in the United States. While anthrax can be infectious to humans, it cannot be transmitted from person to person.

Prior to the fall 2001 cases, the most recent case of inhalation anthrax in the United States was reported in 1976. This was one of only 18 cases of inhalation anthrax reported in the last 100 years. The risk of contracting any of the three types of anthrax remains very unlikely.

*Types of Anthrax**

Types	Cutaneous (Skin) Anthrax	Inhalation Anthrax	Intestinal Anthrax
Background	Cause of most anthrax infections; spores must come in contact with skin lesion or skin wound.	The most severe of the types of anthrax.	Brought on by consuming contaminated meat. No cases of intestinal anthrax have been reported in the past 50 years.
Symptoms	Begins as raised, itchy bump resembling an insect bite. Develops into a blister and then painless ulcer. Fever, swelling, and headache may follow.	May resemble a cold or flu virus, or a cough. Rapidly develops into severe breathing problems and total body function collapse.	Starts with nausea, appetite loss, vomiting, and fever, followed by abdominal pain, vomiting of blood, and severe diarrhea.
Prevention	Wash hands, bandage wounds, and treat blisters.	Most inhalation anthrax exposures have occurred through mailed letters; students should immediately report (and not open) any suspicious mail.	Cook meat well.
Treatment	antibiotics, both for adults and children	antibiotics, both for adults and children	antibiotics, both for adults and children
Fatality	~20 percent	~90 percent	25 to 60 percent

***Sources:** Centers for Disease Control, National Institutes of Health

In discussing anthrax with your students, it may be helpful to clarify some terms students may have heard but not fully understood. Bacteria are microscopic, single-celled organisms. *Bacillus anthracis*, the bacteria that produces anthrax, attacks the body's cells and releases poisons known as toxins. The effects of these toxins are what causes death.

Doctors use substances called antibiotics to kill anthrax bacteria; however, antibiotics cannot neutralize the toxins once they have been released. Vaccines are used to produce immunity against a disease. The anthrax vaccine uses dead anthrax bacteria to stimulate the body to produce antibodies against the disease.

Resources

Book

Miller, Judith, Stephen Engelberg, and William Broad.
Germs.
New York: Simon & Schuster: 2001.
Investigates U.S. and Soviet development of germ warfare during the Cold War, and exposes current bioterror risks and lack of preparedness for biowarfare in the United States.

Articles

Boyer, Peter G.
The Ames Strain.
The New Yorker; November 12, 2001, pp 66–75.
Describes how the anthrax strain known as the Ames strain may have originated in spores from a single cow in Iowa, and how and why it proliferated in germ laboratories.

Preston, Richard.
The Demon in the Freezer.
The New Yorker; July 12, 1999, pp. 44–61.
Explores smallpox, the history of the virus, attempts to eradicate the illness, its transmission and recurrence in 1972, and its legitimacy as a biowarfare threat.

Web Sites

NOVA Online—Bioterror
www.pbs.org/nova/bioterror/
Includes information on the eight lethal biological agents that may pose the greatest threats of biowarfare, answers to frequently asked questions, a timeline of the history of biological warfare, an online activity about making vaccines, and more.

Anthrax Information
www.bt.cdc.gov/
Provides information about anthrax and the current public health emergency response as well as health alerts, advisories, and updates from the Centers for Disease Control.

Anthrax and Bioterrorism Tutorial
www.nlm.nih.gov/medlineplus/tutorials/anthrax.html
Uses a tutorial style to teach general background information about anthrax, such as types of anthrax, symptoms, and treatment.

The Missing Link

Airs Tuesday, February 26, 2002 ○ www.pbs.org/nova/tink/

Program Contents

NOVA follows paleontologists as they search for evidence of how humans evolved legs.

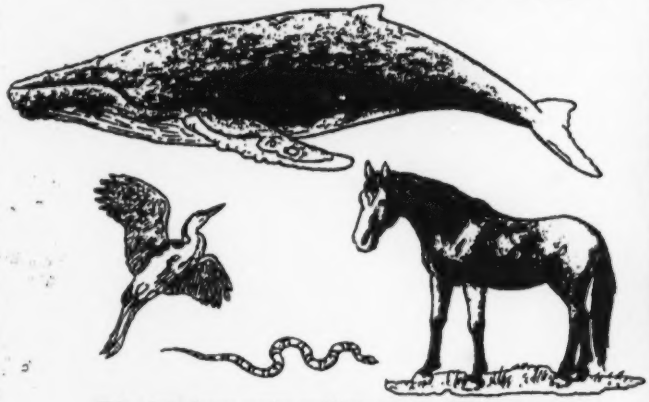
The program:

- surveys 70 years of the search for the first Devonian tetrapod and the fish with legs from which it came.
- follows one scientist's 1930s discovery of a Greenland fossil that he concluded was the first tetrapod and his unwillingness to let anyone else study it for 48 years.
- tells of the 1938 finding of a coelocanth and the subsequent reinterpretation of its role as a transitional form.
- chronicles the discovery of another Greenland tetrapod fossil that was found to have eight digits, not five as expected.
- explains the findings of two more tetrapods within Pennsylvania sandstone that indicated the end of the Devonian Period was characterized by a diverse environment, not a barren one as previously believed.
- gives rise to the possibility that creatures developed limbs so that they could navigate through shallow wetlands.
- shows the serendipitous nature of several key discoveries, including the rediscovery of a previously catalogued fish jaw that exhibited part fish and part tetrapod features.

Before Watching

1. Tetrapods are vertebrate animals with four leg-like appendages. Ask students to define *tetrapod* and list examples of tetrapods from organisms that live on land, in water, and in the air. While students are likely to think of mammals or reptiles with four legs, point out that the tetrapod group also includes modern-day birds, snakes, and other animals with fewer or no appendages.

2. As students watch, ask them to note the dates, evidence, and inference related to each find featured in the program.



This whale, horse, snake, and bird—though different in structure and function—are all considered tetrapods. The animals that no longer exhibit four legs are classed as tetrapods because their ancestors once had four legs.

After Watching

1. Review students' notes about the research finds made from the 1930s to the 1990s. How did the thinking change as to how the first land animals formed limbs? What forces might have led to the evolution of tetrapods?

2. Discuss with students the key dates and finds from the program that they noted. How and why did the thinking change over the years? What do students think about Erik Jarvik's decision to withhold his fossil from study by others for so long? What impact may that decision have had on the research on transitional forms?

Activity Setup

Objective

To collect, analyze, and interpret information about objects in order to classify them into a cladogram.

Materials for each student

- copy of the *Hardware Organism Key* activity sheet on page 23
- copy of the *Cladogram Basics* activity sheet on page 24

Materials for each team

- copy of the *Nailing Cladistics* activity sheet on page 22
- identical plastic bags with one of each of the materials listed on the *Hardware Organism Key* activity sheet on page 23
- 11- x 17-inch sheet of paper

Procedure

1. Biological organisms are traditionally classified according to like, or constant, characteristics. However, to show how organisms have evolved over time to be different, scientists sometimes develop a family tree of how they may have evolved, a method known as cladistics. (See *Activity Answer* on page 25 for more information.) Students will use common nails, screws, and bolts to simulate the process of applying cladistics to living organisms or fossil life forms. **Note:** Point out that students' models will differ from how living organisms actually evolve—the inanimate objects they will be using already have a fixed set of traits and do not represent true biological evolutionary relationship that living organisms exhibit.
2. Collect the materials listed. (You may choose your own "organisms" and create your own organism key, if you prefer.)
3. For Part 1, assign students to teams and provide each team with a plastic bag of the materials and a copy of the *Nailing Cladistics* activity sheet and each student with a copy of the *Hardware Organism Key* activity sheet. Have each team first classify the organisms using a dichotomous key that organizes organisms by constant characteristics. Discuss each team's results and variations among team decisions.
4. For Part II, provide each student with a copy of the *Cladogram Basics* activity sheet, and each team with a large sheet of paper for its final cladogram.
5. Have students list the characteristics of the hardware organisms and make a table of all the traits. Have them analyze and use the information in the table to create rough drafts of their cladograms. Have each team prepare a final cladogram.
6. After all teams have finished, display the cladograms. Have each team explain its cladogram and reasons for where objects were placed. Did all teams agree? Discuss similarities and differences.
7. To conclude, have students compare cladistics and more traditional taxonomy. What are the advantages and disadvantages of each?
8. As an *extension*, have students add other fasteners, such as clamps, to the mix of objects to see how it changes the cladogram.

Standards Connection

The activity found on pages 22–24 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard G:
Life Science

Diversity and adaptations of organisms

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.
- Biological evolution accounts for the diversity of species developed through gradual processes over many generations. Species acquire many of their unique characteristics through biological adaptation, which involves the selection of naturally occurring variations in populations. Biological adaptations include changes in structures, behaviors, or physiology that enhance survival and reproductive success in a particular environment.

Grades 9-12

Science Standard C:
Life Science

Biological evolution

- The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.
- The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors.

Explanation of Hardware Dimensions The numbers below the hardware organisms listed on the *Hardware Organism* Key activity sheet signify:	
Common nail	20d 4-inch = 20d represents 4-inches (10.16-cm)*
Wood and sheet metal screws	10 x 2-inch = #10 screw x 2-inches (5.08-cm)**
Stove bolt, carriage bolt, and machine screws	10-24 x 1-inch = #10 screw-24 thread per inch x 1-inch (2.54-cm)**

* The "d" at one time represented pennyweight and would describe the number of pennies needed to buy 100 nails. A 20d nail is 0.192 inches (0.49–cm) in diameter.
** A #10 screw is 0.190 inches (0.48-cm) in diameter.

Nailing Cladistics

NOVA Activity **The Missing Link**

Cladistics is one way scientists classify organisms. A cladogram shows the nature of evolutionary relationships that may have occurred, similar to a family tree. You will make a cladogram in this activity.

Procedure

Part I

1. Display your set of hardware organisms and match each one to the organisms listed on your *Hardware Organism Key* activity sheet. Make sure you have all the organisms listed.
2. Classify your hardware organisms into groups. On a separate sheet of paper, make a record of your classifications, listing the letter for each organism you have classified. Then list the common characteristics of each of your groups.

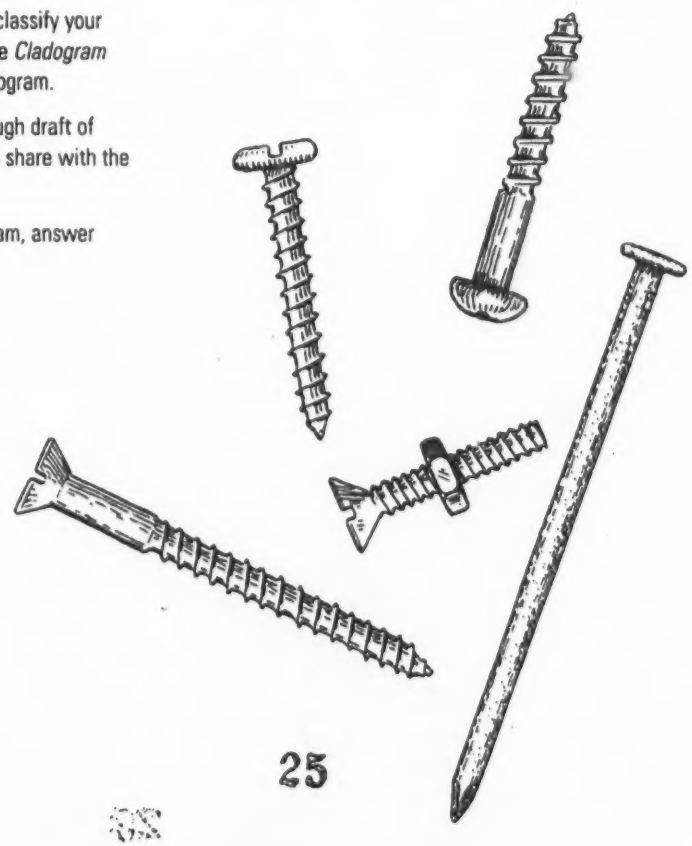
Part II

1. You will now use a different method to classify your organisms. Follow the instructions on the *Cladogram Basics* activity sheet to create your cladogram.
2. After you have created and revised a rough draft of your cladogram, create a final version to share with the class.
3. When you have completed your cladogram, answer the questions.

Questions

Write your answers on a separate sheet of paper.

1. Compare your cladogram with others in the class. Will all correct cladograms be the same? Why or why not?
2. Compare cladistics with the more traditional taxonomy that you did in the Part I of the lesson. How do they differ? What are the advantages and disadvantages of each method?



Hardware Organism Key

NOVA Activity **The Missing Link**

Hardware Organism Key

A

Common Nail
20d 4-inch

B

Flat-head wood screw
10 x 2-inch

C

Flat-head sheet metal screw
10 x 2-inch

D

Flat-head stove bolt
10-24 x 2-inch

E

Flat-head machine screw with nut
10-24 x 1-inch

F

Round-head wood screw
10 x 1¼-inch

G

Round-head sheet metal screw
10 x 1¼-inch

H

Round-head machine screw with nut
10-32 x 1½-inch

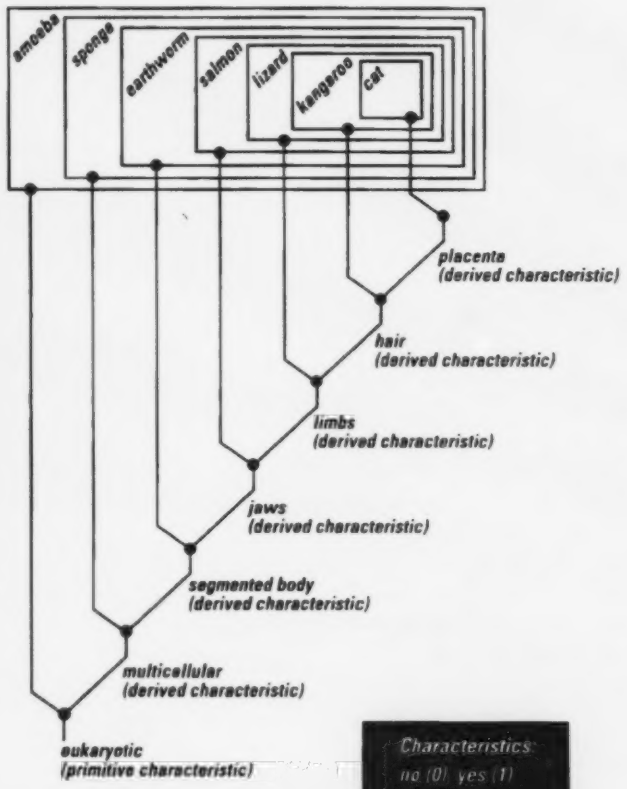
I

Carriage bolt with nut
10-24 x 2-inch

Cladogram Basics

NOVA Activity **The Missing Link**

In cladistics, similar characteristics that come from a common ancestor are used to divide organisms into groups. A cladogram will begin by grouping organisms based on a characteristic displayed by all the members of the group. Subsequently, the larger group, or clade, will contain increasingly smaller groups (clades) that share the traits of the clades before them, but also exhibit distinct changes as the organism evolves. The example that follows represents a cladogram.



Organism	Characteristic # 1	2	3	4	5	6	7
amoeba	(1)	(0)	(0)	(0)	(0)	(0)	(0)
sponge	(1)	(1)	(0)	(0)	(0)	(0)	(0)
earthworm	(1)	(1)	(1)	(0)	(0)	(0)	(0)
salmon	(1)	(1)	(1)	(1)	(0)	(0)	(0)
lizard	(1)	(1)	(1)	(1)	(1)	(0)	(0)
kangaroo	(1)	(1)	(1)	(1)	(1)	(1)	(0)
cat	(1)	(1)	(1)	(1)	(1)	(1)	(1)

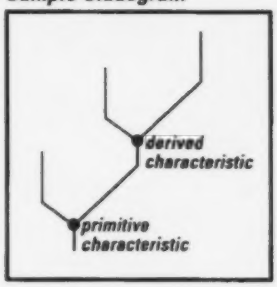
Source: Science at a Distance—Professor John Blamire (www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS Clad.html)

To make a cladogram, scientists first collect data on the features of all the organisms they hope to classify. This data is then analyzed to determine which characteristics were present in what could have been a common ancestor and which might have been developed in later times. Use the following instructions to make a cladogram for your set of hardware organisms.

Procedure

1. Make your cladogram on a separate sheet of paper. Lay out your organisms on a work surface. List all the characteristics you see for each object and make a table of all the traits.
2. Which characteristic do all the objects have in common? This is referred to as a primitive, or original, characteristic. It is of little value in analyzing the relationships within a group since all members possess this characteristic.
3. Again look at the data to determine common characteristics that only a portion of the group has. These are referred to as derived, or advanced, characteristics. They are usually more advanced features that were added to the primitive features found earlier. The largest group of these derived characteristics will be the first to branch from the main trunk of the cladogram. Name the derived characteristic and list all the objects that have that characteristic. Your drawing of the cladogram at this point should look similar to the following:

Sample Cladogram



4. Look for further characteristics that are common to only a portion of the group and add these to the cladogram until the groups can be sorted no further.

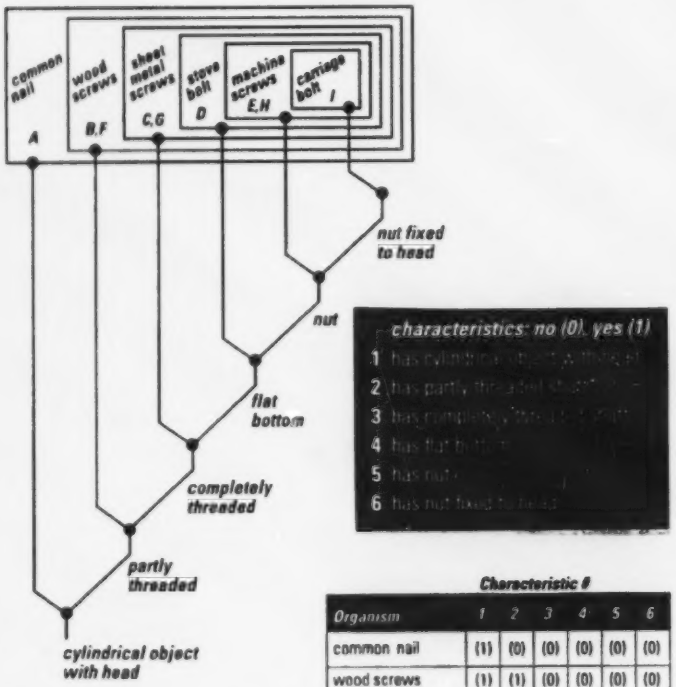
Activity Answer

Cladistics is a way of sorting organisms based on characteristics that were derived from a common ancestor. Cladograms often do not follow the more traditional methods of animal classification. While traditionally dinosaurs might be considered reptiles and birds classified as aves, on a cladogram the two would share the same line. Scientists generally agree that today's birds are evolutionary descendants of the dinosaurs.

Sample Cladogram

The sample represents one possible way the organisms might have evolved; showing evolution by thread count would be another possible way of building the cladogram. In this sample, all organisms are cylindrical, have a head, and have the same pennyweight (10); these traits are known as plesiomorphic (original) and are common to all the organisms. The apomorphic (advanced) characteristics shown below represent the evolutionary characteristics of the organisms.

Some differences might be seen in final team cladograms. Emphasize to the students that to be correct, the evolutionary development must be the basis, that is, the nail came before the screw. Scientists prefer to use the simplest cladogram that gives all the information. Cladograms drawn by scientists evolve as scientists learn more and simplify them.



	Characteristic #					
Organism	1	2	3	4	5	6
common nail	(1)	(0)	(0)	(0)	(0)	(0)
wood screws	(1)	(1)	(0)	(0)	(0)	(0)
sheet metal screws	(1)	(1)	(1)	(0)	(0)	(0)
stove bolt	(1)	(1)	(1)	(1)	(0)	(0)
machine screws	(1)	(1)	(1)	(1)	(1)	(0)
carriage bolt	(1)	(1)	(1)	(1)	(1)	(1)

*Some discussion may arise about completely threaded shafts falling into the partly threaded category and how these might have evolved in relation to one another.

Resources

Books

Pojeta, John Jr., and Dale A. Springer.
Evolution and the Fossil Record.
Alexandria, VA: American Geological Institute, 2001.
Includes information about the fossil record, Darwin's theory, dating the fossil record, examples of evolution, and more. Accessible online at: www.agiweb.org/news/evolution/

Zimmer, Carl.
At the Water's Edge: Fish With Fingers, Whales With Legs, and How Life Came Ashore But Then Went Back to Sea.
New York: Touchstone Books, 1999.
Describes the latest fossil discoveries, outlines an evolutionary chronology, and gives insights into macroevolution.

Web Sites

NOVA Online—The Missing Link
www.pbs.org/nova/link/
Provides program-related articles, interviews, interactive activities, and resources.

Classification
www.brooklyn.cuny.edu/bc/ahp/CLAS/CLAS.HP.html
Explains many different reasons for classification and classification schemes, including cladistics.

Evolution—All in the Family
www.pbs.org/evolution/change/family/
Offers an interactive way to explore evolutionary relationships by building phylogenic trees and learning about "outgroups."

Evolution & the Nature of Science Institutes: Transitional Fossils
www.indiana.edu/~ensiweb/lessons/c.bkgrnd.html
Describes transitional fossils, compares and contrasts features of early "mammal-like" reptiles with those of mammals, explains several reasons for gaps in fossil records, and lists the main findings from the vertebrate fossil record so far.

Program Contents

NOVA chronicles a tale of leadership that marked one of the most remarkable survival stories of all time—that of Sir Ernest Shackleton's 1914 British Imperial Trans-Antarctic Expedition.

The program:

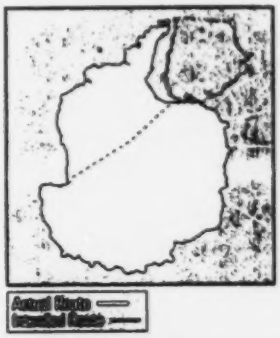
- tells Shackleton's story through archival photos and footage, crewmember diary entries, interviews with crewmembers' relatives, and present-day footage of locations on Shackleton's journey.
- chronicles the physical and psychological state of crew members throughout their journey: as the *Endurance* becomes stuck in pack ice and then sinks; as the men set up their first, and then second, camps on ice; as the crew sets sail in three lifeboats for Elephant Island; and as Shackleton and five others set out in a modified lifeboat in a final bid for rescue.
- details the crew's day-to-day life, including what they ate, what duties they performed, and what they did for recreation.
- shows the strong loyalties crew members had for Shackleton, who they fondly called "The Boss," and what the consequences were of disobeying orders or creating dissent.
- explores the leadership decisions Shackleton made that led to the eventual rescue of his entire crew.

Before Watching

1. Have students locate Antarctica in an atlas and identify the following locations featured in the program: South Georgia Island, the Weddell Sea, Elephant Island, and Punta Arenas, Chile.

2. Shackleton's leadership is legendary. To help students see how his leadership traits are played out by real-life decisions, assign students to groups to take notes on Shackleton's decisions regarding the following: daily life; food distribution; the journey's progress; and crew morale.

3. To help students understand some of the decisions Shackleton had to make, have them do the *Weighty Decisions* activity on page 27 before watching.



Shackleton originally intended to land at Vahsel Bay and head southwest toward the Ross Sea. His actual route was much different—because the *Endurance* became stuck in pack ice, Shackleton and his crew remained in the Weddell Sea, never actually setting foot on the continent.

After Watching

1. Ask students to identify Shackleton's key decisions during the expedition. (Some decisions may emerge in more than one category.) List all of the decisions on the chalkboard and have students identify the 10 most valuable ones. (You may want to use the *Timely Decisions* poster in the center of this guide to help students with their lists.) As a class, have students group the decisions into traits (for example, choosing crew members based not just on experience but also on personality, representing good team building). Which traits do students think are most important for a leader faced with life-threatening decisions? Why?

2. The men on this journey at times faced incredible psychological and physical hardships. Have students make a timeline highlighting some of those crisis points and note how Shackleton handled them.

Activity Setup

Objective

To decide what to rescue from the sinking *Endurance* and compare those decisions to ones made by Sir Ernest Shackleton.

Materials for teacher

- transparency copy of the *Weighty Decisions* activity sheet on page 28
- transparency marker

Materials for each student

- copy of the *Weighty Decisions* activity sheet on page 28 (plus an additional copy for each group)

Procedure

1. Before watching, organize students into groups and supply a copy of the *Weighty Decisions* activity sheet to each student, and an additional copy to each group. Students will be prioritizing items to take from the *Endurance* before it sinks, just as Shackleton had to.
2. Allow students time to review their choices of items for the journey before them. Then have students individually fill out their activity sheets. When done, have students in each group discuss their choices with their group members and reach a consensus about what to take from the ship.
3. Have students fill out the additional group activity sheet with their final choices and answer the Group Questions section before returning the sheet to you.
4. Using each group's activity sheets and your transparency copy, place a dot in the first, second, or third priority box for each item each group has ranked. When you have recorded each group's decisions, hold a class discussion on any differences of opinion.
5. Have students watch the program. When the program is finished, review Shackleton's choices and the explanations for each of those. (See *Activity Answer* on page 29.) Were there any decisions students would change to be the same as or different from Shackleton's? If so, which ones and why?
6. As an *extension*, have students list people they consider leaders in such areas as politics, sports, business, and society. What are their qualities? What traits seem to recur when students describe these people? What traits might these people have that could be detrimental to effective leadership?

More Shackleton Activities

Want more activities that relate to Shackleton's infamous journey? You can download the 24-page *Shackleton's Antarctic Adventure Teacher's Guide* that accompanies a giant-screen film on this legendary leader's journey. find the guide and upcoming film locations at: **www.shackletonsantarcticadventure.com**

Standards Connection

The activity found on page 28 aligns with the following *National Science Education Standards*.

Grades 5-8

Science Standard C:
Life Science

The characteristics of organisms

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms.

Grades 9-12

Science Standard C:
Life Science

The behavior of organisms

- Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism's own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli.

Funding for "Shackleton's Voyage of Endurance" is provided by Morgan Stanley.
Morgan Stanley

Weighty Decisions

NOVA Activity **Shackleton's Journey of Endurance**

In this activity, you are Sir Ernest Shackleton and your ship, the *Endurance*, has been frozen in the pack ice of Antarctica's Weddell Sea for nine months. It's clear that soon the *Endurance* will sink due to the pressure of the ice surrounding it. An enormous challenge is before you. What will you take with you and what will you leave behind?

Procedure

① Below is a list of items that you can salvage from the *Endurance* before she sinks. You cannot possibly move everything across the ice, so you must choose wisely those things that are crucial. Twenty-seven men and 70 dogs are on your expedition.

② As you make your choices, keep in mind that you don't know how long you will be stranded.

③ Check each item as 1st, 2nd, or 3rd priority in the boxes beside each. First priority items must be included for survival. Second and third priority items may be left behind because their function can be achieved through other means or because they take space away from more important items.

Group Questions

Write your answers on a separate sheet of paper.

① What were the principles and guiding questions that drove your group's decisions?

② Which items were most difficult to agree on?

③ How did your group resolve any differences of opinion?

Endurance Inventory

1	2	3	Item	1	2	3	Item	1	2	3	Item
			Artist's oil paints				Journals and pencils				Sextant
			Books				Knives				Ship's bell
			Camera, film				Matches				Signal mirror
			Canned meat				Medical supplies				Sledges and dogs
			Compass				Pistols, cartridges				Soccer ball
			Cooking pots				Playing cards				Star charts
			Cotton shirts				Radio				Stove
			Extra kerosene				Reindeer skin sleeping bags				Tents
			Extra lamp wicks				Rifles, cartridges				Tools
			Flare Pistol				Rope				Wooden crates
			Fresh water in canisters				Sail canvas				Woolen long underwear

Activity Answer

Here are some of the decisions Shackleton made regarding which items should be taken from the sinking *Endurance* (compiled from written accounts of Shackleton's journey).

1	2	3	Item	1	2	3	Item
1			Artist's oil paints			3	Radio
1			Books	1			Reindeer skin sleeping bags
	2		Camera, film	1			Rifles, cartridges
	2		Canned meat	1			Rope
1			Compass	1			Sail canvas
1			Cooking pots	1			Sextant
		3	Cotton shirts			3	Ship's bell
1			Extra kerosene			3	Signal mirror
1			Extra lamp wicks			3	Sledges and dogs
		3	Flare Pistol			3	Soccer ball
	2		Fresh water in canisters			3	Star charts
	2		Journals and pencils	1			Stove
1			Knives		2		Tents
1			Matches	1			Tools
1			Medical supplies	1			Wooden crates
		3	Pistols, cartridges	1			Woolen long underwear
1			Playing cards				

Shackleton's first concerns were for the necessities of life. Penguins and seals were easily hunted with rifles (1), so canned meat (2) was unnecessary. Pistols however, would have been dead weight (3).

Fresh water (2) was essential, but heavy and bulky. Although sea ice is salty, glacial ice, iceberg fragments, and snow are plentiful sources of fresh water if there is a stove (1), kerosene (1), matches (1), and cooking pots (1) to melt them in.

Shelter includes staying warm. Rope (1) has many uses, including making replacement shelter for the flimsy tents (2) from sail canvas (1). Woolen long underwear (1) and reindeer skin sleeping bags (1) are warm when wet because they trap air. Cotton shirts (3) stay saturated and cold.

Some choices depended on the journey. The pack ice proved to be too rough for sledges (3), and the dogs required too many provisions.(They were shot.) The lamp wicks (1), and artist's oil paints (1) were used to caulk the lifeboats and the tools (1) and wooden crates (1) were essential to maintain the lifeboats.

Navigation to South Georgia depended on sextant (1) sightings of the Sun, not stars; so star charts (3) were unnecessary. The value of medical supplies (1), knives (1), and a compass (1) are obvious.

Calling for help was not an option. Radio (3) was in its infancy in 1916, and Shackleton was too far from any rescuers for a signal mirror (3), a ship's bell (3), or a flare pistol (3) to be useful.

Shackleton was also concerned about the mental health of his men and included playing cards (1) and books (1) to help them through times when they were forced to lie low. Perhaps this explains why the extra weight of journals and pencils (2), and a camera and film (2) were permitted. But the soccer ball (3) would see little opportunity for use under these conditions.

Resources

Books

Alexander, Caroline.
The *Endurance*: Shackleton's Legendary Antarctic Expedition.
Bloomsbury, U.K.: Knopf, U.S.A., 1998.
Blends detailed research with Frank Hurley's expedition photography to chronicle the 22-month epic of survival.

Huntford, Roland.
Shackleton.
New York, NY: Carroll & Graf, 1998.
Offers a comprehensive biography of Sir Ernest Shackleton.

Lansing, Alfred.
***Endurance*: Shackleton's Incredible Voyage.**
New York, NY: Carroll & Graf, 1999.
Reconstructs the months of hardship and terror the Endurance *crew suffered.*

Kimmel, Elizabeth Cody.
Ice Story: Shackleton's Lost Expedition.
New York, NY: Clarion Books, 1999.
Follows the series of disasters that constitute Shackleton's adventure.

Shackleton, Ernest, and Peter King (ed.)
South: The Last Antarctic Expedition of Shackleton and the *Endurance*.
New York, NY: The Lyons Press, 1998.
Presents Shackleton's own account of his odyssey.

Web Sites

NOVA Online—Shackleton's Voyage of Endurance
www.pbs.org/nova/shackleton/
Documents the PBS/NOVA Online Adventure that documents the filming of Shackleton's story.

Shackleton's Legendary Antarctic Expedition
www.amnh.org/exhibitions/shackleton/expedintro.html
Features one-page summaries of each stage of Shackleton's adventure.

Sir Ernest Henry Shackleton
indigo.ie/~jshack/ernest.html
Provides links to information in all forms about the explorer, including books, video and film, upcoming exhibitions, and related Internet sites.

Program Contents

Americans have long engaged in an ongoing struggle against one of the most important ecological forces of nature—wildfires. NOVA follows an elite firefighting team through the 2000 fire season, one of the fieriest in U.S. history.

The program:

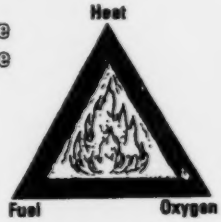
- introduces the Arrowhead Hotshots, an elite team of wildfire fighters from California, and tracks the team's efforts through the season.
- focuses on the months-long effort to control a massive fire in Clear Creek, Idaho, the largest single wildfire in the year 2000.
- reveals the ecological benefits and importance of fire to wildland systems.
- documents major wildfires from the past century, emphasizing the lessons learned from each encounter.
- explains the development of modern wildfire fighting methods and the technology, equipment, and strategies that are employed to control wildfires.
- details the enormous role that weather plays in wildfires.
- documents a comprehensive wildfire research project in the Alaskan wilderness.
- examines the debate among supporters of various firefighting policies, raising the possibility that some environmental policies have created forests where wildfires are hotter, burn faster, and spread more quickly than they did 100 years ago.

Before Watching

1. Ask students what kind of fires they have seen or heard about. Have students brainstorm the similarities and differences between a structural fire and a wildland fire. What skills are necessary for firefighters in each setting? What equipment is necessary?

2. Discuss with students why and when wildland fires might be beneficial or detrimental. What are some reasons for letting a wildfire burn uncontrolled? Why would firefighters want to stop it? What reasons might there be to burn wildland in a controlled manner? What are the disadvantages of setting controlled fires?

The Fire Triangle



A fire cannot exist without heat, fuel, and oxygen. Managing one or more of these elements helps firefighters contain an unwanted fire or guide a prescribed fire.

After Watching

1. Have students consider what they think about prescribed burning. Who or what is affected by it? Do students agree or disagree with the use of prescribed burning? Under what conditions would students propose a prescribed burn? What factors would be important to consider?

2. Tragic events such as the Oklahoma City bombing and the World Trade Center attacks have highlighted the heroic roles of urban firefighters. Do students consider wildland firefighters heroes? Why or why not?

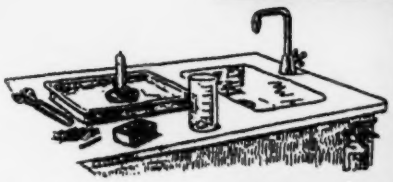
Fire Wars Special Section

This special 12-page section accompanies the two hours of the NOVA program, "Fire Wars."

Contents	page
Teacher Demonstrations	31
Student Activities	32–37
Activity Answers	38–39
Resources	40–41

Teacher Demonstrations

Objective
To explore the conditions needed for combustion to occur.



Materials for teacher
Demonstration I
- metal pan
- candle firmly in holder
- matches
- heat resistant glass beaker (large enough to fit over the candle)
- tongs
- safety glasses
- steel nail
- small piece of super fine steel wool

Demonstration II
- long matches

Procedure
Demonstration I

1. Wear safety glasses during the entire demonstration and do not allow students to crowd around the demonstration table. Tell students they will be investigating the components necessary to allow a fire to burn. Before you do the demonstration, have students consider these questions: In a wildland area, which would burn more quickly: small trees and brush, or large trees? Why?
2. Have students describe what they know about the chemical process of fire. What do all fires have in common? What components are needed for combustion?
3. To help students understand how combustion occurs, place the candle in the metal pan, light the wick and let the candle burn for 10 seconds. Then put the glass beaker over the candle until it goes out.
4. Discuss with students what made it possible for the candle to burn. Specifically, what components were needed for fire to ignite and be sustained? (See *Activity Answers* on pages 38–39 for more information.) What could have been done to prolong the fire?
5. Now have students predict whether a steel nail or steel wool will burn. Following their predictions, attempt to burn the nail. (*The nail may become covered with soot, but will not burn.*) Next, stretch out a small piece of compacted steel wool, and use the tongs to hold the steel wool over the flame. (*The steel wool will quickly light and burn.*)
6. Both items are made up of the same material—steel. Why did the steel wool burn but not the nail? Revisit the question from the start of the demonstration: Based on what they saw burn in class, would small trees and brush or large trees burn more quickly? Why?
7. Ask students what might happen if all small fires were extinguished? (*Suppression can lead to a buildup of fuels available for fire, which can lead to bigger fires.*) What might happen if all fires were allowed to burn uncontrolled? (*A loss of lives, property, and wildlands.*) Point out that not all fires are detrimental; fire may be necessary to keep some wildlands healthy. Land managers and firefighters must consider a number of factors when deciding to fight a fire or recommend a prescribed burn. (See *Activity Answers* on pages 38–39 for more information.)

Procedure
Demonstration II

1. Tell students you will be demonstrating an aspect of fire behavior. Show students the long match you will light and ask them how fast the fire will travel if the match is level, if the match is angled with the match head pointing up, and if the match is angled with the match head pointing down.
2. Once students have replied, light the match and conduct the demonstration. (*If level, the fire moves along steadily; with match head up, the fire moves downward more slowly because the heat is flowing away from, rather than toward, the wood fuel source; and with match head down, the fire moves quickly upward as the wood fuel source is directly heated and engulfed by the flame.*) (See *Activity Answers* on page 38–39 for more information.)

Standards Connection
Grades 5-8/9-12
Science Standard B: Physical Science

Safety Note
The candle should be in a supported, stable base. Make sure you are following the rules for your school's usage of fire in the classroom, such as providing an area:
- with a working sink and fire extinguisher nearby.
- with a noncombustible surface.
- clear of flammable items, such as books or papers.

Activity 1 Setup

Objective

To identify fire risk factors for a property located near a wildland area.

Materials for team

- copy of the *Where Growth Meets Growth* activity sheets on pages 34–35
- colored pencils

Procedure

1. One of the issues surrounding wildland fires involves areas where uncontrolled urban growth meets uncontrolled vegetative growth. People who live in these areas should take extra precautions to limit the effects of any nearby wildland fire that might occur. Students will take on the role of Fire Marshal for a house that requires a safety evaluation.
2. Review with students some of the types of ecosystems that could be subject to wildland fire under these circumstances. (See *Activity Answers* on pages 38–39 for more information.)
3. Organize students into teams and distribute a copy of the *Where Growth Meets Growth* activity sheet and colored pencils to each team.
4. Have students identify, number, and provide reasons for areas of increased risk they think should be changed. Have students consider changes that may mean adding or taking something away from the property that is not currently featured in the illustration.
5. When teams are finished, compile everyone's results on the chalkboard, categorize the measures, and review them. What are the benefits of these changes? Which changes would students make first and why?
6. As an *extension*, have students survey and identify areas of their towns that may be most at risk for fire.

Standards Connection

The activity found on pages 34–35 aligns with the following National Science Education Standards.

Grades 6-8

Science Standard F:
Science in Personal and Social Perspectives

Natural hazards

- Internal and external processes of the earth system cause natural hazards, events that change or destroy human and wildlife habitats, damage property, and harm or kill humans. Natural hazards include earthquakes, landslides, wildfires, volcanic eruptions, floods, storms, and even possible impacts of asteroids.

Risks and benefits

- Risk analysis considers the type of hazard and estimates the number of people that might be exposed and the number likely to suffer consequences. The results are used to determine the options for reducing or eliminating risks.

Grades 9-12

Science Standard F:
Science in Personal and Social Perspectives

Natural and human-induced hazards

- Natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society, as well as cause risks. Students should understand the costs and trade-offs of various hazards—ranging from those with minor risk to a few people to major catastrophes with major risk to many people. The scale of events and the accuracy with which scientists and engineers can (and cannot) predict events are important considerations.

Activity 2 Setup

Objective

To extrapolate information and further questions for investigation from fire season statistics.

Materials for team

- copy of the *Fire Season Statistics* activity sheets on pages 36-37
- calculator

Procedure

1. Having information about previous fire seasons can help land managers look for areas they may need to monitor in coming years. In this activity, students will look at data regarding wildland fire totals for the year 2000 as reported by the National Interagency fire Center.
2. Organize students into groups and provide each group with a copy of the *Fire Season Statistics* activity sheets and a calculator.
3. Have each group discuss the data as it is currently presented. What information is conveyed? What general conclusions can students draw? What, if any, patterns do they see? How might the data be reconfigured to illustrate different aspects of the data set? (One avenue of inquiry is suggested in the questions section on the activity sheet.)
4. Have groups decide how to present the information in a meaningful way. Students might consider tables, bar graphs, pie graphs, or some other way to represent the data. Based on what they find in the data, what kind of campaign would they design to reduce wildland fires?
5. What additional information would students want in this data set? What points would they like clarified?
6. As an *extension*, have students look at and compile weekly situation reports for each month published online by the National Interagency Coordination Center. How many fires and acres burned were there each month? Where did the largest fires occur? How do each month's totals compare to the prescribed fire totals for that month? Find the reports at: **www.cidi.org/wildfire/**

Standards Connection

The activity found on pages 36–37 aligns with the following *Principles and Standards for School Mathematics*.

Grades 6-8

Number and Operations
Data Analysis and Probability

Grades 9-12

Data Analysis and Probability

Where Growth Meets Growth

NOVA Activity **Fire Wars**

This house you are evaluating is situated in an area of uncontrolled urban growth that borders on an area of uncontrolled vegetative growth. People who live in these areas should take extra precautions to limit the effects of any nearby wildland fire that might occur. As the local Fire Marshal team, you have been called in to evaluate the safety of a house and its property. The owner has left so that you can conduct your inspection. What will you recommend?

Procedure

1. Identify and number all the areas of increased risk in this house and surrounding property. Be sure to consider changes that may mean adding or taking something away from the property that is not currently pictured.
2. In the space below, write down the reasons you believe each numbered area is at risk.

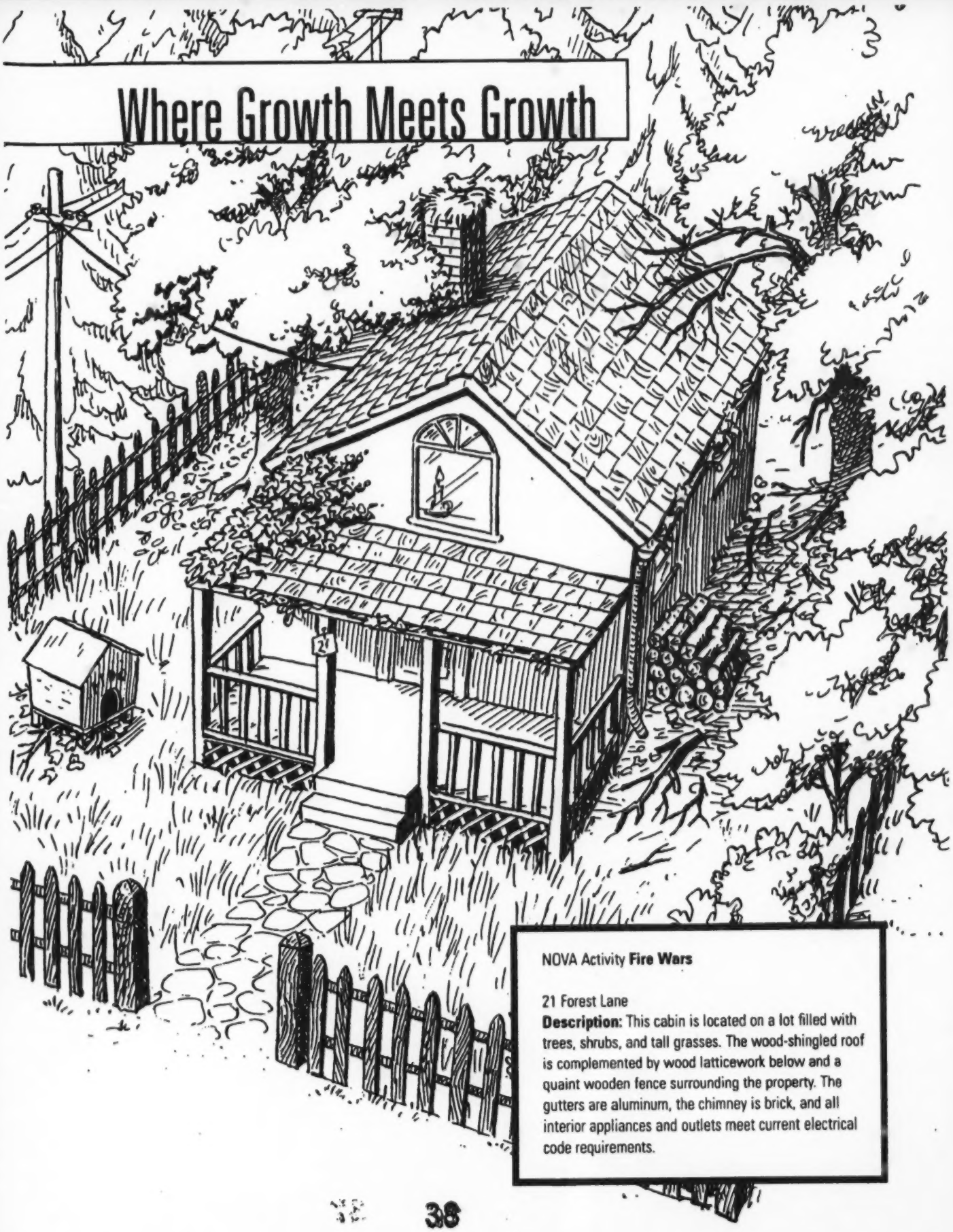
Risk Assessment Form

Date: _____

Areas of Increased Risk:

Submitted by the following Fire Marshal team:

Where Growth Meets Growth



NOVA Activity **Fire Wars**

21 Forest Lane

Description: This cabin is located on a lot filled with trees, shrubs, and tall grasses. The wood-shingled roof is complemented by wood latticework below and a quaint wooden fence surrounding the property. The gutters are aluminum, the chimney is brick, and all interior appliances and outlets meet current electrical code requirements.

Fire Season Statistics

NOVA Activity **Fire Wars**

The National Interagency Fire Center, a partnership among government agencies that helps states and towns fight fires, has released its tallies on all recorded wildland fires for the year 2000 season. Your job is to make sense of the numbers. Look at the data below and see what it can tell you.

		Bureau of Land Mgt.	Bureau of Indian Affairs	Fish and Wildlife Service	National Park Service	USDA Forest Service	State/Private
NATURALLY CAUSED							
Lightning	Fires	2,567	1,293	185	342	6,371	7,659
	Acres	1,355,209	258,658	217,162	101,013	1,676,414	1,218,187
HUMAN CAUSED							
Prescribed	Fires	485	33	1,068	111	2,954	*
	Acres	125,600	3,353	201,052	19,072	728,237	*
Camping	Fires	64	109	47	56	1,260	1,876
	Acres	84,152	1,401	1,931	16,082	52,467	18,953
Smoking	Fires	23	160	31	23	237	3,418
	Acres	4,038	20,295	15,098	83	15,930	44,951
Incendiary	Fires	57	707	89	61	817	25,259
	Acres	60,294	18,465	6,609	13,522	157,144	847,914
Equipment	Fires	121	180	75	36	194	10,107
	Acres	16,856	7,712	97,479	1,387	8,311	308,681
Railroads	Fires	10	10	12	13	56	2,711
	Acres	86	47	476	338	55,561	85,260
Juveniles	Fires	11	631	13	14	65	3,193
	Acres	117	14,762	1,041	80	211	12,729
Misc.	Fires	257	1,440	177	138	866	49,786
	Acres	50,112	190,121	8,800	18,142	172,872	1,165,084
GRAND TOTALS							
Natural and Human	Fires	3,595	4,563	1,697	794	12,820	104,009
	Acres	1,696,464	514,814	549,648	169,719	2,867,147	3,701,759

Source: National Interagency Fire Center Web site
www.nifc.gov/fireinfo/2000/stats.html
* State/Private data not available.

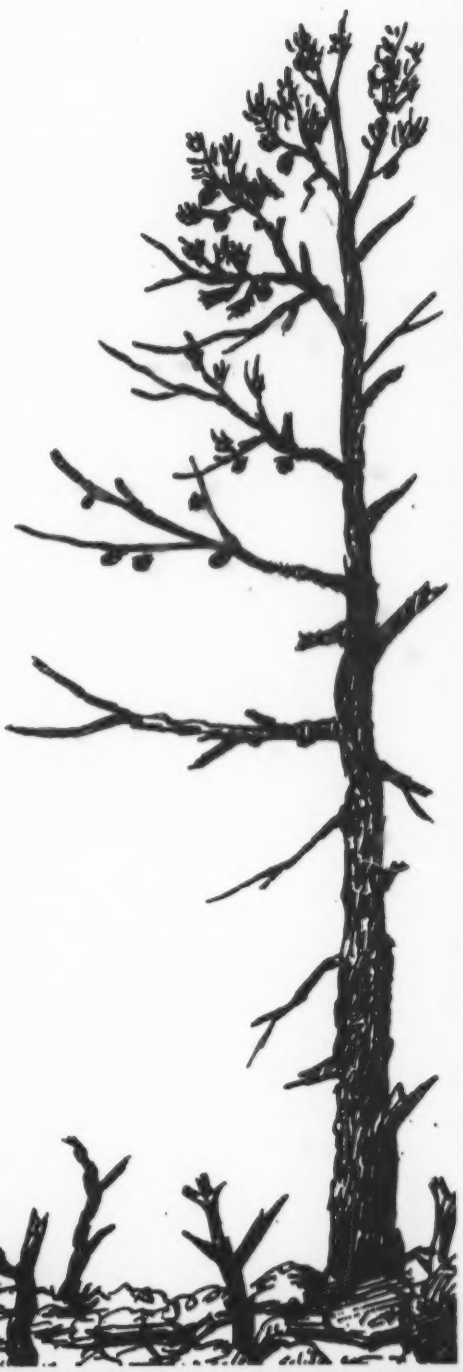
Fire Season Statistics

NOVA Activity **Fire Wars**

Questions

Write your answers on a separate sheet of paper.

1. Look at this data. What does it tell you in its current form? Calculate all totals for the data set and choose a way to represent them, using bar graphs, pie graphs, or some other presentation method.
2. Which source is the cause for the most fires? What source of fire is responsible for the most acres damaged? Which source has the highest fire-to-acres-burned ratio?
3. Considering human causes of fire only, and excluding the miscellaneous category, which source is the cause for the most fires? Which source is responsible for the most acres damaged? Which source has the highest fire-to-acres-burned ratio?
4. Which source was the cause of the fewest fires? What source is responsible for the fewest acres damaged? Which source has the lowest fire-to-acres burned ratio?
5. The 10-year average number of fires (1990-1999) was 106,393. The 10-year average of acres burned during the same period was 3,786,411. What does this information tell you when compared to the year 2000 totals?
6. What are some conclusions you could draw from the facts above?
7. What questions do you have about the data presented in this data set? What additional information would you like in order to test your conclusions?



Activity Answers

Wildland fires are not limited to densely populated forests. They can occur in a number of ecosystems, including:

Major Ecosystems*

Ecosystem	Sample Location	Vegetation Type
Boreal Forest	Denali National Park & Preserve, Alaska	Spruce, pine, and fir dominate northern areas to tree line. Large, intense fires recur every 25 to 150 years.
Chaparral	Santa Monica Mountains National Recreation Area, California	Mixed shrubs and low trees grow in dense masses. Explosive fires scour the hillsides bare every 12 to 50 years.
Ponderosa Pine	Grand Canyon National Park, Arizona	Spacious forests of trees hundreds of years old. Frequent fires (5 to 25 years) clear ground but seldom kill large trees.
Lodgepole Pine	Yellowstone National Park, Idaho, Montana, and Wyoming	Dominant tree in the park, this pine grows in dense stands. Sections burn wholly every 200 to 400 years.
Tallgrass Prairie	Tallgrass Prairie National Preserve, Kansas	Surviving flames better than invasive brush, the grass is renewed by frequent large fires that can out-run a horse.
Appalachian Mixed Forest	Great Smoky Mountains National Park, Tennessee and North Carolina	Conifers and deciduous trees mingle in shifting ratios as determined by climate and a mosaic of rare fires.
Longleaf and Loblolly Pines	Cumberland Island National Seashore, Georgia	Southern pines grow in grassy park-like stands. Mild surface fires clear debris every 3 to 5 years.
Wetlands	Big Cypress National Preserve, Florida	Saw grass needs fire to kill competing vegetation. Small patches burn to the waterline every 1 to 25 years.

*Reprinted with permission from the National Park Service

At the turn of the century, there was no agency responsible for fighting wildland fires, which at the time were believed to be unmanageable. It wasn't until 1905, when the Forest Service assumed control over the national forests, that a major debate arose over appropriate fire management strategy—whether to suppress all fires or carry out regular controlled burning. A disastrous 1910 fire season contributed to the decision to fight all forest fires. The debate resurfaced in the 1960s, when critics contended that under the right circumstances prescribed or controlled natural fires can aid natural biotic processes and help reduce the risk of extreme fires due to excess fuel accumulations. However, prescribed burns have their own drawbacks; they can saturate large pockets of air with smoke and they can escape control.

Teacher Demonstrations

Demonstration I

Fire is a combination of heat, fuel, and oxygen. The match serves as the ignition source, which provides the heat necessary to ignite the fuel (the wax). The heat liquifies the wax, which is drawn up by the wick to fuel the fire. finally, as demonstrated by the flame going out after the beaker is placed over the candle, the fire requires some component in the air. That component is oxygen.

Scientists have refined their understanding of these three components. They know that for a material to ignite, it must first reach its ignition temperature, which depends on such factors as a material's properties, density, and surface area. While a candle flame does not provide enough heat for a nail to reach its ignition temperature (whereas a blast furnace might), it can easily cause a thin strand of steel wool to reach ignition temperature. (Soot that builds up on the nail is merely unburned carbon from the candle.) The nail is representative of a thick tree trunk, while the steel wool represents the smaller fuel sources like tinder found in forests. Both can burn, but one can be ignited more easily than the other.

In order to contain a fire, firefighters must lower the heat, remove the fuel source, or deplete the oxygen. Structural firefighters often use water to lower the heat, while wildland firefighters often try to remove the fuel source. Other factors that allow fire to start and spread include weather (wind, temperature, and relative humidity), and the topography of the affected area

Demonstration II

The fire traveled most quickly when the match head was pointed down, demonstrating how slope affects fire behavior. Fire can blast up slopes, which is why firefighters are taught they cannot outrace an uphill blaze.

Student Activities

Activity 1—Where Growth Meets Growth

The following are some measures that can be taken to protect a house from wildland fire.

1. Remove leaves and rubbish under doghouse and any other structures.
2. Stack firewood at least 100 feet away and uphill from the house.
3. Water and mow grass regularly to keep it green and less flammable.
4. Rake flammable vegetation such as dead leaves, limbs, branches, twigs, and grass clippings.
5. Have power company clear branches from lines.
6. Prune tree branches within 15 feet of a chimney outlet.
7. Clean chimneys at least once a year.
8. Make sure roof uses fire-resistant materials such as asphalt, fiberglass, concrete tile, clay tile, or metal.
9. Remove dead branches that extend over the rooftop.
10. Clean gutters regularly.
11. Remove vines from exterior walls.
12. Arrange trees so that there are gaps in the canopy.
13. Any part of property that includes wood, such as fence, latticework, or facing should be changed. Alternatives include a stone fence, brick or concrete as a porch front and, concrete or clay tiles on the house dormer.
14. Address should be clearly posted for firefighters to see.
15. Never leave a flame burning unattended.

Additional measures:

- Situate the house on flat land; the steeper the slope, the faster the fire will move up it.
- Make sure there is open access for firefighters to reach the property.
- Plant fire-resistant shrubs and vegetation.
- Add an independent water supply.
- Add a swimming pool.

Activity 2—Fire Season Statistics

A first step could be to collapse the data into total fires and total acres. Students' data analysis will differ depending upon what they choose to highlight.

Students will likely have a number of additional questions prompted by the data set, such as:

- What is each agency's jurisdiction? Is there any overlap in fires reported?
- What were the data collection strategies? Were they the same for all agencies?
- What systems were in place to ensure data reliability?
- Specifically, what kind of fires are included in each of the categories?
- What kind of fires are included under each of the other human-caused fire categories?
- Why was state/private data not included for prescribed fires? Is that data available elsewhere?

Resources

Books

Dilsaver, Larry, and William Tweed.
Challenge of the Big Trees: A Resource History of Sequoia and Kings Canyon National Parks.
Tucson, AZ: University of Arizona Press, 1991.
Presents an environmental history of the giant sequoias and explores the role of fire and the issue of biological conservation. Includes maps and an annotated bibliography.

Fuller, Margaret.
Forest Fires: An Introduction to Wildland and Fire Behavior, Management, Firefighting, and Prevention.
New York: John Wiley & Sons, Inc., 1991.
Provides and introduction to forest fires and fire ecology.

Junger, Sebastian.
Fire.
New York: W. W. Norton & Company, 2001.
Describes raging forest fires in the Western United States and other dangerous situations at home and abroad.

Leschak, Peter M.
Hellroaring: The Life and Times of a Fire Bum.
East Peoria, IL: North Star Press of St. Cloud, Inc., 1994.
Chronicles the author's adventures as a forest firefighter.

Maclean, John N.
Fire on the Mountain.
New York: William Morrow and Co., 1999.
Depicts and analyzes the deadly 1994 fire at Storm King Mountain.

Maclean, Norman.
Young Men and Fire.
Chicago: University of Chicago Press, 1993.
Describes the disaster at Mann Gulch in 1949; considered a classic in firefighting.

Patent, Dorothy Hinshaw.
Fire: Friend or Foe.
New York: Clarion Books, 1998.
Discusses the pros and cons of fire on the ecosystem and examines differing views and policy recommendations about firefighting and controlled burning.

Pyne, Stephen J.
Fire in America: A Cultural History of Wildland and Rural Fire.
Seattle: University of Washington Press, 1997.
Chronicles the history of fire in the United States; the first of six books in the author's Cycle of fire series.

Pyne, Stephen J.
Fire on the Rim: A Firefighter's Season at the Grand Canyon.
Seattle: University of Washington Press, 1995.
Presents a firsthand account of the author's firefighting days.

Pyne, Stephen J.
Year of the Fires: The Stories of the Great Fires of 1910.
New York: Viking, 2001.
Describes the Great Fires of 1910 through eyewitness accounts of the rangers, soldiers, politicians, bureaucrats, scientists, and civilians; and shows how virtually all modern firefighting policies originated from the experiences of 1910.

Sholly, Dan R. and Steven M. Newman.
Guardians of Yellowstone: An Intimate Look at the Challenges of Protecting America's Foremost Wilderness Park.
New York: William Morrow and Company, Inc., 1991.
Describes the fight to protect the land and people of Yellowstone National Park during the forest fires of 1988.

Taylor, Murray A.
Jumping Fire: A Smokejumper's Memoir of Fighting Wildfire.
New York: Harcourt, Inc., 2000.
Recounts the author's 20 years of fighting wildfires in the American West.

Web Sites

NOVA Online—Fire Wars
www.pbs.org/nova/fire/
Provides program-related articles, interviews, interactive activities, and other resources.

Earth Observatory
earthobservatory.nasa.gov/Newsroom/MediaResources/Wildfires/
Shows view of wildland fires from space.

Employment and Careers in Forestry
forestry.about.com/cs/employment/
Lists links devoted to finding employment resources in the areas of forestry and natural resources, including an article about finding firefighting employment online.

Fire & Aviation Fire Reports
www.fs.fed.us/fire/reports.shtml
Provides daily fire reports from agencies such as the National Interagency fire Center, the U.S. Forest Service, and the National Park Service. Also includes archived monthly situation reports dating back to 1994.

Fire Ecology
www.nps.gov/fire/fire/ecology/docs/toc.html
Includes background information about fire ecology, a Teacher's Guide with activities and quizzes, and a glossary of fire terms and additional references.

Fire Globe
www.ruf.uni-freiburg.de/fireglobe/
Includes links to global, regional and national fire weather and climate forecasts; near-real time global fire data; and international forest fire news.

Fire Management Today
www.fs.fed.us/fire/planning/firenote.htm
Provides online issues of Fire Management Today. Topics include wildland fire in communities, wildland fire prevention, wildland fire weather, the role of fire in wildlands, and more.

Fire Management Tools Online
fire.org/perl/tools.cgi
Provides access to a collection of documentation, visuals, graphics, notices, and software contributed by and for the wildland fire management community.

FireNet
www.nps.gov/fire/index.htm
Offers information about wildland fire training and employment with the National Park Service and provides links to other National Park Service sites that contain specific park-related fire information.

Firewise
www.firewise.org/fw99/home.html
Includes daily National Interagency Fire Center Incident Management Situation Report, peak fire seasons map, materials for educators, and more.

Forestry
forestry.about.com/mlibrary.htm
Offers information about forest fires and prescribed burning.

National Interagency Fire Center
www.nifc.gov/
Features wildland fire statistics, current wildland fire information, and other useful links.

Wildfire News
www.wildfirenews.com/
Offers information about fire ecology, a fire danger map, regional reports, and links to additional resources. The section "So You Want to Be a Wildland Firefighter?" highlights some of the qualifications for a career in fighting wildland fires.

Wildland Fire in Yellowstone
www.nps.gov/yell/technical/fire/index.htm
Provides history and ecology of wildland fires in Yellowstone.

Wildland Fire Operations
www.fs.fed.us/fire/operations/index.shtml
Describes the different command operations used for a fire that falls under more than one agency's jurisdiction. Also includes information about hotshot and helitack crews, smokejumper operations, and more.

Yellowstone Fires and Their Legacy
www.idahonews.com/yellowst/yelofire.htm
Features a comprehensive guide to the 1988 Yellowstone fires.

NOVA Video Catalog

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These videos have been categorized by their primary content strand; many programs are interdisciplinary. You may want to scan several categories for videos of interest.

WGBH BOSTON VIDEO

Earth & Space Science

Apollo 13: To the Edge and Back

The gripping, true story of the catastrophic flight of the *Apollo 13* and the heroic struggle to bring the astronauts back alive. With first-hand accounts from the pilots, their families and the people of mission control, it documents a thrilling struggle against time and all odds.
1.5 hrs. **WG514 $19.95**

Chasing El Niño!

Lethal ice storms, droughts, floods and devastation—what in the world is going on here? *NOVA* explores the myths, reveals the devastation, explains the fascinating facts and provides a new climate for understanding the ultimate weather machine.
1 hr. **WG2512 $19.95**

Cracking the Ice Age

The Himalayas, towering over the Tibetan plateau, are one of the world's most magnificent sights. But could they also be the cause of one of the planet's most dramatic climatic changes—the Ice Age? *Educational use only.*
1 hr. **WG2320* $19.95**

NEW! Death Star

NOVA joins baffled astronomers as they try to track down the source of mysterious bursts of powerful radiation from space. Discovered by satellites looking for surreptitious nuclear explosions on Earth, the blasts seem to come from all parts of the sky.
1 hr. **WG35663 $19.95**

NEW! Fire Wars

Filmed during the disastrous fire season of 2000, *Fire Wars* joins smokejumpers as they battle to contain the worst wildfire outbreaks in half a century. This *NOVA* special combines spectacular action scenes with a provocative look at the long relationship between humans and fire—a relationship that is forcing us to make increasingly difficult ecological and social choices. *Available Summer 2002.*
2 hrs. **WG35603 $19.95**

Flood!

Relive one of the greatest flood disasters—the Mississippi River in the summer of 1993—and explore the problem of taming the mightiest river.
1 hr. **WG2307 $19.95**

Natural Disasters Boxed Set

Natural disasters strike with little or no warning—making them uniquely frightening and fascinating. Includes *The Day the Earth Shook, Tornado!*, and *In the Path of a Killer Volcano.*
3 hrs. on 3 cassettes. **WG165 $49.95**

Nature's Fury Boxed Set

Witness the awesome power of nature. Includes *Hurricane!, Lightning!* and *Killer Quake!*
3 hrs. on 3 cassettes. **WG027 $49.95**

Runaway Universe

NOVA presents the dramatic quest to unlock secrets of the stars as two rival teams search for exploding stars, map gigantic cosmic patterns of galaxies, and grapple with the ultimate question: what is the fate of the universe?
1 hr. **WG2713 $19.95**

Space Explorers Boxed Set

Step on the moon. Float in space. Explore the final frontier. *NOVA* assembles three of its most acclaimed space adventures to create this special four-hour set. Includes *To the Moon, Terror in Space* and *Rescue Mission in Space.*
4 hrs. on 3 cassettes. **WG667 $49.95**

Stationed in the Stars

Go inside the planning, assembly and excitement of history's most ambitious and expensive engineering venture—a hugely ambitious "orbiting city" set for completion in 2004. *Educational use only.* 1 hr. **WG2708 $19.95**

*No Retail Packaging

Terror in Space

Through candid interviews and spectacular previously unreleased footage, *NOVA* exposes what really happened aboard the orbiting disaster known as the *Mir* space station and see what made the *Mir* link-up one of the most dangerous missions in NASA history.
1 hr. **WG2513 $19.95**

To The Moon

Rare interviews and amazing footage capture America's full-thrust effort to be the first to the moon and the history of the *Apollo* space program.
2 hrs. **WG2610 $19.95**
DVD 2 hrs. **WG998 $19.95**

What's Up with the Weather?

In this special two-hour program, *FRONTLINE* and *NOVA* take on one of the most complex and important challenges facing the world today—global warming. Take a dramatic journey to find out what's in store for our Earth's climate system.
2 hrs. **WG904 $19.95**

General Science

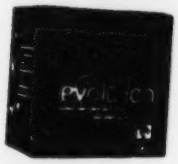
NEW! Bioterror

In September 2001, three leading journalists on the staff of *The New York Times* published the provocative and disturbing results of their investigation into biological weapons. For months, *NOVA*'s cameras followed the journalists as they pursued their inquiries. *Bioterror* reveals for the first time how the US planned to bomb Cuba with biological weapons during the 1961 missile crisis, tours abandoned germ war factories built on a frightening scale by the former Soviet Union, and takes an exclusive look at current US work on bioweapons.
1 hr. **WG35563 $19.95**

Escape! Because Accidents Happen Boxed Set

In the air, at sea, on the road, or in your home, you must be prepared to escape! *NOVA* goes behind the sensational headlines to examine the fascinating science of "survival engineering." Includes *Fire, Car Crash, Plane Crash* and *Abandon Ship*.
4 hrs. on 4 cassettes. **WG260 $49.95**

Evolution



Evolution offers a groundbreaking and definitive view of the extraordinary impact the evolutionary process has had on society and culture around the world. Beginning with Darwin's revolutionary theory, this seven-part series explores all facets of evolution, such as the changes that spawned the tree of life, the power of sex, how evolution continues to affect us every day, and the perceived conflict between science and religion. The seven-part series includes: *Darwin's Dangerous Idea, Great Transformations, Extinction!, The Evolutionary Arms Race, Why Sex?, The Mind's Big Bang,* and *What About God?*.
8 hrs. on 7 cassettes. **WG1158 $99.95**
8 hrs. on 4 DVDs. **WG35469 $99.95**

Learning and Teaching Evolution

Teaching high school biology will never be the same! The *Evolution* project offers a wide variety of multimedia resources to enhance teaching and learning, including this video which offers a variety of educational approaches for teachers, and engaging science for students designed to help them grasp basic evolutionary concepts. Seven short segments (*Evolving Ideas: Videos for Students*) combine storytelling and science to explore the concepts of evolution and spark students' interest in the topic. And four additional segments (*Teaching Evolution Case Studies*) highlight a range of strategies for teaching evolution in classrooms across the country, including ways to successfully and respectfully address the controversy that can arise.
2 hrs. **WG1302 $19.95**

Ice Mummies Boxed Set

You're there as the ice mummies are unearthed, as clothing and artifacts are studied, and as mysteries of the Stone Age are explained. Includes *Frozen in Heaven, Siberian Ice Maiden* and *Return of the Iceman*.
3 hrs. on 3 cassettes. **WG2525 $49.95**

In Search of Human Origins Boxed Set

The award-winning exploration of the beginnings and expansion of the human race. Includes *The Story of Lucy, Surviving in Africa* and *The Creative Revolution*.
3 hrs. on 3 cassettes. **WGW2111 $49.95**

Lost King of the Maya

For 400 years, Yax K'uk Mo's dynasty of Blood Lords presided over the Maya city of Copan, though generations of scholars have dismissed the story as pure myth. But now a team of archaeologists may have found his tomb. Will these archaeologists' discoveries transform the legend of Yax K'uk Mo from myth into reality?
1 hr. **WG2804 $19.95**

NEW! The Missing Link

According to the theory of evolution, all four-limbed animals—everything from human beings to dinosaurs—are descended from a single creature, the first to crawl from water onto land. Yet finding that vital bridge between fish and four legs has proven elusive. A paleontological tour-de-force and suspenseful scientific detective story, *The Missing Link* follows a trail of clues from Pennsylvania to Greenland, including the crucial rediscovery of a tiny fossil jaw that had lain unnoticed in a dusty museum drawer for decades. *Educational use only. Available March 2002.*
1 hr. **WG35573 $19.95**

Mysterious Mummies of China

Perfectly preserved 3,000-year-old mummies have been unearthed in a remote Chinese desert shedding new light on the contact between the East and West in the ancient world. But these don't appear to be the ancestors of the modern-day Chinese people—they have long, blonde hair and blue eyes.
1 hr. **WG2502 $19.95**

Neanderthals on Trial

Were Neanderthals human ancestors or an evolutionary dead-end? After more than a century of investigation, the jury is still out. Exploring one of the most contentious debates in human origins, *NOVA* offers a surprising look at how the science works, and how investigators sometimes fool themselves into seeing what they want to see. *Available February 2002.*
1 hr. **WG2815 $19.95**

Russia's Nuclear Warriors

Russia's 6,000 nuclear warheads are aging and unreliable. Some experts claim these failing systems could plunge the world into doomsday—by accident. Vladimir Pozner, a leading Russian journalist and Kremlin insider for decades, offers an ominous glimpse into Russia's national security through unprecedented access to military officers and the first footage filmed inside the country's biggest nuclear missile base.
1 hr. **WG35113 $19.95**

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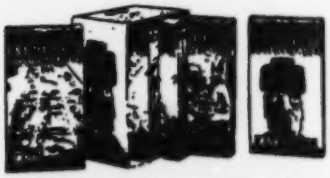
NEW! Secrets, Lies & Atomic Spies

NOVA reveals startling new evidence that Soviet spies penetrated America's deepest secrets, including the Manhattan Project, in the 1940s. By cracking the code of Soviet diplomatic cables, the FBI was able to hunt down "atom spies" such as Klaus Kuchs and Julius Rosenberg. But the true "master spy," a physicist named Ted Hall, got away—and his gripping story is presented for the first time by *NOVA*.
Available March 2002.
1 hr. **WG35553 $19.95**

Secrets of Lost Empires Boxed Set

Uncover the secrets of ancient civilizations as *NOVA* journeys to five archaeological sites where teams of experts use traditional techniques to test their hypotheses. Includes *Colosseum, Inca, Obelisk, Stonehenge* and *Pyramid.*
5 hrs. on 5 cassettes. **WG182 $69.95**



Secrets of Lost Empires II Boxed Set

Filled with powerful recreations and revealing insights, this ambitious *NOVA* series examines five ancient civilizations and their unique impact on the past...and on the future. Includes *Medieval Siege, Pharaoh's Obelisk, Easter Island, Roman Bath* and *China Bridge.*
5 hrs. on 5 cassettes. **WG898 $69.95**

NEW! Shackleton's Voyage of Endurance

In 1914, Ernest Shackleton boarded the *Endurance* with a team of seamen and scientists, determined to be the first to cross the Antarctic continent. But when the pack ice closed in and crushed their frail wooden ship, Shackleton and his men found themselves stranded 1200 miles from civilization with little hope of rescue. For the next 14 months, they set out on a harrowing journey across the ice, subsisting mainly on penguin and seals. When the ice broke up, Shackleton saved his men by embarking on a heroic 800-mile voyage in a tiny rowboat across the treacherous south Atlantic. Amazingly, all Shackleton's men survived their ordeal. Although many are now familiar with this epic story, *NOVA* presents a definitive two-hour documentary that includes spectacular footage of Antarctic locations and moving interviews with descendants of the original expedition team.
Educational use only. Available April 2002.
2 hrs. **WG35583 $19.95**

Submarines, Secrets & Spies

NOVA lifts the veil on deadly, mysterious submarine accidents and high-risk spy missions through candid interviews with Soviet and U.S. military personnel, shocking underwater footage and recently declassified film and documents.
1 hr. **WG2602 $19.95**

Sultan's Lost Treasure

In the South China Sea, prospectors spot an ancient shipwreck. A team of archaeologists dives down to retrieve a unique treasure–more than 12,000 intact pieces of Chinese porcelain. The priceless cargo poses countless riddles as they seek the identity of the ship and the meaning of the strange and delicate symbols on the dishes. *Educational use only.*
1 hr. **WG2601 $19.95**

The Tribe That Time Forgot

NOVA travels deep into the Amazon wilderness to search for a mysterious tribe that dismembered and partially ate three prospectors in 1976. 1 hr. **WG2115* $19.95**

The Vikings

This riveting two-hour special investigates a new image of the Vikings that goes far deeper than their savage stereotype as raiding marauders. Faithful replicas of their magnificent ships, life-like computer animation and fascinating recreations reveal the Vikings as canny merchants, expert shipbuilders, superb artisans, and bold colonizers of lands that lay beyond the edge of the known world.
2 hrs. **WG958 $19.95**

Warriors of the Amazon

See a rare glimpse of life today for the Yanomami, who live in a remote and inhospitable part of the Amazon rain forest.
1 hr. **WG2309 $19.95**

Life Science

18 Ways to Make a Baby

Experience the frustrations and joys the reproductive revolution is offering families as *NOVA* examines the impact science and technology are having on human lives. Meet the couples—and their babies—entering this brave new world, as well as the doctors and biologists on the leading edge of reproductive science.
Educational use only. 1 hr. **WG2811 $19.95**

Animal Hospital

Go behind the scenes for this offbeat, sometimes humorous, sometimes sad portrait of pets, their owners and their vets and the drama that unfolds everyday in homes, zoos and veterinary hospitals.
1 hr. **WG2504 $19.95**

The Brain Eater

Scientists race to determine whether a variant of mad cow disease spells a deadly epidemic for humans. *Educational use only.*
1 hr. **WG2505* $19.95**

Cancer Warrior

NOVA follows Dr. Judah Folkman as he pioneers a cancer treatment long dismissed by many in the cancer-research community. Finally, a scientist in Folkman's lab formulates Endostatin, which eradicates tumors in mice. Will it be as successful in humans?
1 hr. **WG2805 $19.95**
DVD. 1 hr. **WG1310 $19.95**

Cracking the Code of Life

NOVA investigates the complex implications of the human genome project and the incredible impact that its discoveries will have on life in the 21st century.
2 hrs. **WG2809 $19.95**

Dinosaur Hunt Boxed Set

Of all the creatures that ever walked the earth, none captures the human imagination like the dinosaur. To some of us they are almost mythical, a modern-day version of the dragons and monsters of fairy tales. But to scientists they hold a different fascination, offering important clues to the mystery of the evolution of life. Includes *Curse of T. rex, Case of the Flying Dinosaur* and *T. rex Exposed.*
3 hrs. on 3 cassettes. **WG737 $39.95**

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Dying to Be Thin

Tormented by an irrational fear of being fat, an estimated eight million young women are torturing themselves—sometimes to death. *Dying to Be Thin* introduces you to students, ballet dancers, fashion models and other young women who are seeking recovery or have conquered their disease. Discover how leading eating disorder specialists are making dramatic advances in the diagnosis and treatment of these two devastating diseases.
1 hr. **WGZ707 $19.95**

Ebola: The Plague Fighters

The Ebola virus and its devastating impact is profiled as *NOVA* travels behind the quarantine line to observe the scientists battling to contain this most deadly of viruses.
1 hr. **WGZ304 $19.95**

Flying Casanovas

Male bowerbirds go to outrageous lengths to create intricately constructed "stage sets" and "art collections" designed specifically to impress the opposite sex. Travel to Australia and New Guinea with legendary naturalist David Attenborough to explore the remarkable displays, some adorned with bright flowers, elaborate stickwork, colorful feathers, shells, bugs, and even "painted" walls.
1 hr. **WGZ818 $19.95**

Garden of Eden

The Seychelles, often referred to as the Garden of Eden, is a stunningly beautiful island chain. This tropical archipelago off the coast of Kenya is home to a dazzling array of exotic plants and animals and is also a scientific wonderland due to the incredibly unspoiled nature of the islands and their wildlife.
1 hr. **WGZ714 $19.95**

Kingdom of the Seahorse

Witness a remarkable fish whose male becomes pregnant and gives birth. Tour the magical and complex world of the seahorse—from an underwater enclave in Australia to a village in the Philippines dependent on the seahorse for survival.
1 hr. **WGZ410 $19.95**

Little Creatures Who Run the World

Peer close-up into the worlds of the most amazing ants and understand why some believe ants are the most successful life form on earth.
1 hr. **WGZ203 $19.95**

Methuselah Tree

Discover what a 4,600-year-old tree can teach scientists and historians about our past, present and future. Travel to a top-secret location high in the White Mountains of California and explore our stunning past through the life of the Methuselah Tree, a 26-foot bristlecone pine that quietly holds the title of "Oldest living thing on earth."
1 hr. **WGZ817 $19.95**

The Miracle of Life

This Emmy® award-winning classic brings you along on an incredible microphotographic voyage through the human body as a new life begins, including the moment of conception.
1 hr. **WG001 $19.95**
DVD 1 hr. **WG799 $19.95**

Night Creatures of the Kalahari

When the sun sets over southern Africa, the grasslands' strangest and most secretive residents sneak out from their lairs. Witness bush babies, meerkats, striped polecats, brown hyenas, flying termites, and more rarely seen exotic creatures. *Educational use only*
1 hr. **WGZ501 $19.95**

The Private Lives of Dolphins

Discover the deep-sea drama of life for the ocean's most charming and sophisticated mammals.
1 hr. **WG1917 $19.95**

Search for a Safe Cigarette

With unprecedented access to tobacco research and manufacturing facilities, *NOVA* takes a rare look inside the tobacco industry and its attempts to create a safer cigarette. Trace the little-known history of "reduced risk" cigarettes, explore America's love affair with smoking, and examine efforts by the tobacco industry to confront its toxic products.
1 hr. **WGZ810 $19.95**

Secrets of the Mind

A blind man can see. Another feels pain in his missing arm. One believes he's God. In this remarkable *NOVA*, pioneering brain detective V.S. Ramachandran, hailed as "the Sherlock Holmes of neuroscience," tackles mysterious cases and delivers mind-boggling conclusions.
1 hr. **WGZ812 $19.95**

Sex: Unknown

Delve into the mysterious world of gender identity as *NOVA* offers a stunning look at the fateful consequences of assigning gender to infants with abnormal genitalia. Includes candid, heartrending interviews with Janet Reimer and her son, who rejected his surgically created female identity and now lives as nature intended: as a male. *Educational use only*
1 hr. **WGZ813 $19.95**

Shark Attack!

Are sharks developing a taste for human flesh? Join *NOVA* scientists as they discover some surprising truths about the way sharks kill.
1 hr. **WGZ316 $19.95**

Surviving AIDS

Journey with *NOVA* to meet the scientists, physicians, and courageous patients whose cutting-edge experimentation and heroic acts will help achieve the ultimate goal: transforming every AIDS patient into a long-term survivor.
1 hr. **WGZ603 $19.95**

Survivor MD

This intimate portrait of a group of young doctors explores their growing expertise, struggles to balance professional and family life, and reflections on an arduous and uplifting decade of training.
3 hrs. on 2 cassettes.
WGZ806 $29.95

Treasures of the Great Barrier Reef

Visit Australia's greatest natural wonder, and view the undersea world's brilliant colors and extraordinary inhabitants.
1 hr. **WGZ215 $19.95**

The Universe Within

Travel on an extraordinary visual tour inside the human body, with microphotography and computer animation achieved by the creators of *The Miracle of Life*.
90 min. *Educational version* **WGZ206A* $19.95**
1 hr. **WGZ206 $19.95**

The Wonder of Life Boxed Set

Hidden from the human eye, the wonder of life unfolds in, on and around us with startling beauty and unexpected drama. Includes *The Odyssey of Life Set (The Ultimate Journey, The Unknown World, The Photographer's Secrets)* and *The Miracle of Life*.
4 hrs. on 4 cassettes. **WG177 $59.95**

Physical Science

The Best Mind Since Einstein

A profile of the late Richard Feynman—atomic bomb pioneer, Nobel prize-winning physicist, acclaimed teacher and all-around eccentric. *Educational use only*. 1 hr. **WGW708* $19.95**

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Building Big with David Macaulay Educational Curriculum

Explore large structures and what it takes to build them with this new five-part series. Hosted by David Macaulay, the award-winning author and illustrator of *The Way Things Work* and other books, each one-hour program focuses on a type of construction integral to modern life: bridges, tunnels, dams, skyscrapers, and domes. Discover the stories behind famous structures and their builders, plus how engineers today are building bigger than ever before. Each video also includes a short vignette featuring kids doing a simple hands-on engineering activity. Educators can easily re-create these activities using the printed instructions that are included. Also included is a short video for middle-school students that explores a key theme from the series, and a 40-page, full color activity guide.
6 hrs. on 6 cassettes. **WG982 $99.95**

Einstein Revealed

Journey into the life and thoughts of a genius—through interviews with "Einstein" (Andrew Sachs of *Fawlty Towers*), insight from experts, and some whimsical computer animation.
2 hrs. **WG2311 $19.95**

NEW! Fireworks!

Fireworks are best-viewed, like a sparkler, at arm's length: close enough to be beautiful, powerful, and alluring, yet far enough away to be safe. This explosive *NOVA* presents the colorful history of pyrotechnics and reveals the chemical secrets that put the bang in the rocket and the fizz in the Roman candle. The show introduces a gallery of firework creators and pyromaniacs, and reveals how hi-tech firing systems are transforming public displays into a dazzling, split-second science.
Available February 2002.
1 hr. **WG35613 $19.95**

Kaboom!

Experience the ultimate chemical reaction—the explosion. With high-speed photography and dramatic reconstructions, *NOVA* examines the history of explosives and their role in accidents, war and terrorism.
1 hr. **WG2401 $19.95**

Race to Catch a Buckyball

Learn about the chance discovery of an entirely new form of carbon—soccer-ball-shaped miraculous molecules called Buckyballs. *Educational use only.*
1 hr. **WG2216* $19.95**

Roller Coaster!

The thrill of the world's greatest rides and the science that creates them. *Educational use only.*
1 hr. **WGW706* $19.95**

Super Bridge

Take a look at "the bridge of the future" and play sidewalk supervisor on one of the world's most remarkable and risky bridge projects—the building of the elegant, cable-stayed Clark Bridge spanning the Mississippi at Alton, Illinois.
2 hrs. **WG2416 $19.95**

Mathematics

The Proof

Princeton math whiz Andrew Wiles spent eight secluded years perfecting the proof of Fermat's Last Theorem, a famous enigma that had stumped experts for 300 years. Follow a fascinating tale of obsession, secrecy, brilliance—and one man's inspiring single-minded quest. *Educational use only.* 1 hr. **WG2414 $19.95**

Trillion Dollar Bet

NOVA follows the riches-to-rags story of two Nobel Prize-winning economists whose mathematical formula to accurately predict financial markets brought them both notoriety and disgrace. *Educational use only.*
1 hr. **WG2704 $19.95**

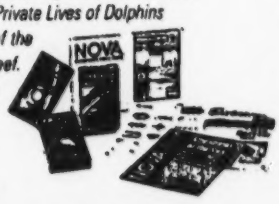
NOVA Field Trips

Amazing Animals

From bugs to bats and more. Includes *All-American Bear, Little Creatures Who Run the World* and *Mystery of the Animal Pathfinders.* Teacher's guide included.
3 hrs. on 3 cassettes. **WG089 $49.95**

Creatures of the Sea

Dive deep for an underwater visit with the ocean's most fascinating creatures. Includes *Shark Attack!, Private Lives of Dolphins* and *Treasures of the Great Barrier Reef.* Teacher's guide included.
3 hrs. on 3 cassettes.
WG091 $49.95



Discovering Ancient Cultures

Investigate new clues for ancient cultures. Includes *This Old Pyramid* (90 min.), *Vikings in America* and *Warriors of the Amazon.* Teacher's guide included. *Educational use only.*
3.5 hrs. on 3 cassettes. **WG092 $49.95**

The Doctors

Watch doctors operate behind the scenes. Grades 7 and up. Includes *MD: The Making of a Doctor* (2 hrs.) and *Ebola: The Plague Fighters.* Teacher's guide included.
3 hrs. on 2 cassettes. **WG104 $49.95**

The Earth

A close-up look at some of Earth's most spectacular phenomena. Includes *In the Path of a Killer Volcano, The Day the Earth Shook* and *Flood!.* Teacher's guide included.
3 hrs. on 3 cassettes. **WG110 $49.95**

Exploring Space

View the universe from new perspectives. Includes *Countdown to the Invisible Universe, Death of a Star* and *Rescue Mission in Space.* Teacher's guide included.
3 hrs. on 3 cassettes. **WG107 $49.95**

Fast Physics

Understand the thrill and power of motion. Includes *Roller Coaster!, Fast Cars* and *Daredevils of the Sky.* Teacher's guide included. *Educational use only.*
3 hrs. on 3 cassettes. **WG088 $49.95**

Flight

Feel the exuberance and the thrill of flight. Includes *Top Gun Over Moscow, Three Men and a Balloon* and *Aircraft Carrier!.* Teacher's guide included. 3 hrs. on 3 cassettes. **WG111 $49.95**

Health Matters

Explore heath issues—from the serious to the unknown. Includes *Dying to Be Thin, Surviving AIDS* and *The Unknown World.* Teacher's guide included.
3 hrs. on 3 cassettes. **WG1156 $49.95**

The Human Body

The intricate wonders of the human body are revealed in extraordinary visual detail. Includes *The Miracle of Life, The Universe Within* and *The Ultimate Journey.* Teacher's guide included.
3.5 hrs. on 3 cassettes.
WG085 $49.95

In Search of Human Origins

The development of the human race. Includes *The Story of Lucy, Surviving in Africa* and *The Creative Revolution.* Teacher's guide included.
3 hrs. on 3 cassettes. **WG109 $49.95**

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Math Mysteries

Explore some of math's greatest mysteries. Includes *The Proof, Lost at Sea: The Search for Longitude* and *Decoding Nazi Secrets*. Teacher's guide included. *Educational use only.* 4 hrs. on 3 cassettes. **WG1155 $49.95**

The Mysteries of the Mind

Explore the intriguing phenomena of perception, psychological development, and reports of alien abductions. Includes *Kidnapped by UFOs, Secret of the Wild Child* and *Stranger in the Mirror*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG105 $49.95**

The Planets, The Stars and More

Visit extraordinary places in the universe. Includes *Venus Unveiled, Eclipse of the Century* and *Doomsday Asteroid*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG087 $49.95**

Scientific Detectives

Search for answers to intriguing mysteries. Includes *Codebreakers, Hunt for the Serial Arsonist* and *In Search of the First Language*. Teacher's guide included. *Educational use only.* 3 hrs. on 3 cassettes. **WG090 $49.95**

Secrets of Lost Empires

Travel to five archaeological sites with *NOVA* and their teams of experts. The mission? To replicate ancient engineering feats—using traditional tools. Includes *Stonehenge, Inca, Obelisk, Colosseum* and *Pyramid*. Teacher's guide included. 5 hrs. on 5 cassettes. **WG304 $69.95**

Weird Weather

Weather phenomena that will leave you wondering! Includes *What's Up with the Weather?, Chasing El Niño* and *Warnings from the Ice*. Teacher's guide included. 4 hrs. on 3 cassettes. **WG1157 $49.95**

Wild Weather

Join "stormchasers" on a journey into danger to learn how to tame nature's fury. Includes *Lightning!, Tornado!* and *Hurricane!*. Teacher's guide included. 3 hrs. on 3 cassettes. **WG088 $49.95**

Instructional Videos

Fast Cars Modules Set

Understand cars to understand physics. *Invisible Forces of Winds* puts students at the controls of an Indy 500 race car to demonstrate aerodynamics. *To Survive at High Velocity* demonstrates how vectors show how "corners make the driver and the car." *Test Day* lets you understand the complexity of race cars by testing every variable on the track. In *A Racing Engine for the Indy 500*, two companies battle to harness energy to create power. Teacher's guide included. *Educational use only*. 1 hr. on 4 cassettes. **WGZ208A* $49.95**

Learning That Works

A unique three-video set and an 80-page comprehensive facilitator's guidebook that demonstrates the benefits of learning science with real world applications. *Learning That Works* presents options for teaching science that integrates what students learn in their science classes with what they do at work or in the community. 2 hrs. on 3 cassettes. **WG983 $99.95**

Physics By Inquiry

Physics By Inquiry: A Video Resource illustrates a hands-on, inquiry-oriented approach to the study of science that can strengthen teachers' understanding of basic physics and physical science and help them begin to teach through inquiry. 90 min. **WG969 $19.95**

Science First Hand Set

Observe teachers and students at work. *Structures* – Designing houses, bridges and towers to explore force, tension and compression. *Tops and Yo-Yos* – Understanding rotational motion by designing and building tops and yo-yos. *Waterwheels* – Simple machines that demonstrate efficiency, speed and testing variables. Teacher's guide included. *Educational use only.* 105 min. on 3 cassettes. **WG005 $39.95**

Science K-6: Investigating Classrooms

Step inside three elementary classrooms to see what teachers from around the country are doing to incorporate in-depth investigations into their science lessons. This library of nine videos and a 110-page Facilitator's Guide are an invaluable resource in learning and refining the fine craft of teaching by observing and discussing real classrooms. The teachers offer themselves and their students as case studies in an effort to raise questions and inspire discussions about what it takes to prepare scientifically literate students. 7 hrs. on 9 cassettes. **WG545 $199.95**

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Feedback

We'd like to know what you think about NOVA, this *Teacher's Guide*, and our online activities. Please write to:

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Sincerely,

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President, Sprint PCS

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